



## The Effect of Future Diet on Bioenergy Availability

Gregg, Jay Sterling; Calvin, Katherine ; Hvid, Anna

*Publication date:*  
2012

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Gregg, J. S. (Author), Calvin, K. (Author), & Hvid, A. (Author). (2012). The Effect of Future Diet on Bioenergy Availability. Sound/Visual production (digital) <http://iew2012.odandbrown.co.uk/files/2012/06/prGregg.pdf>

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



# The Effect of Future Diet on Bioenergy Availability

Jay S. Gregg

Katherine Calvin

Anna Hvid

# Overview

---

- ▶ **Question:**
  - ▶ What is the effect of diet on land use and bioenergy potential?
  
- ▶ **Part I. Bioenergy Potential**
  
- ▶ **Part II. Historical Trends**
  - ▶ 1. Total Caloric Intake
  - ▶ 2. Percentage of Animal Products in the Diet
  - ▶ 3. The Developed vs. Developing World
  
- ▶ **Part III. Future Scenarios**
  - ▶ 1. GCAM
  - ▶ 2. Scenario Development
  - ▶ 3. Results

# Part I. Bioenergy Potential

---



# Bioenergy Potential

---

- ▶ **Technical (Theoretical) Potential** – total amount that can theoretically produced
- ▶ **Supply Potential** – often used interchangeably with technical, but could also vary if one considers sustainability constraints
- ▶ **Demand Potential** – amount of biomass demanded by the global market at a given price or under a given policy scenario, in consideration of other energy options



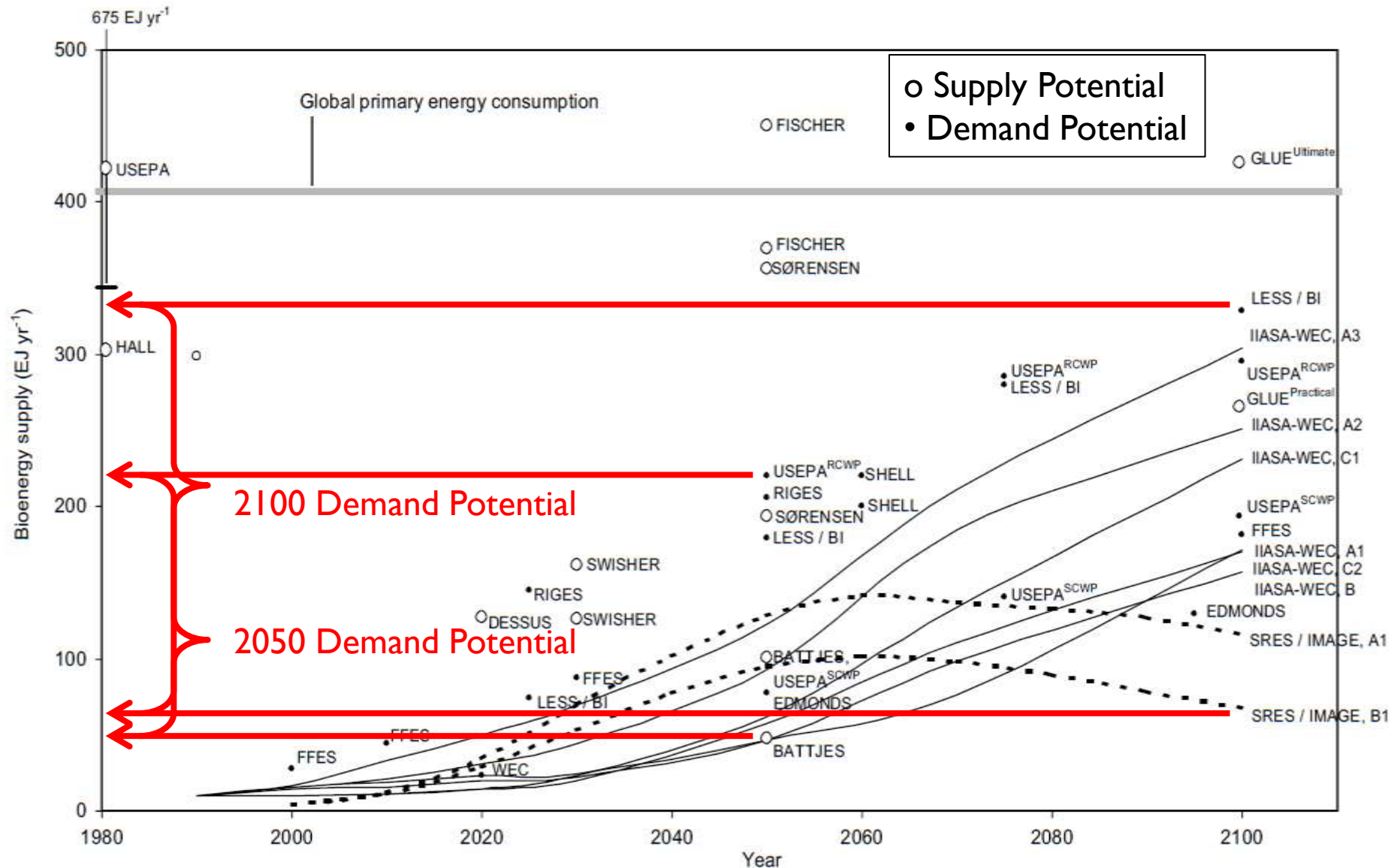


Fig. 2. Potential biomass supply for energy over time. Resource-focused studies are represented by hollow circles and demand-driven studies are represented by filled circles. USEPA and HALL, who do not refer to any specific time, are placed at the left side of the diagram. IIASA-WEC and SRES/IMAGE are represented by solid and dashed lines respectively, with scenario variant names given without brackets at the right end of each line. The present approximate global primary energy consumption is included for comparison. (The global consumption of oil, natural gas, coal, nuclear energy and hydro electricity 1999–2000 was about 365 EJ yr<sup>-1</sup> [43]. Global biomass consumption for energy is estimated at 35–55 EJ yr<sup>-1</sup> [44–46].)

# Issues Affecting Bioenergy Potential

Table ES.2 Overview of uncertainties and their impact on biomass resource potentials\*

Issue/effect	Importance	Impact on biomass potentials compared to	
<i>Supply potential of biomass</i>		<i>supply as estimated in recent studies</i>	<i>OECD baseline scenario in IMAGE</i>
Improvement agricultural management	***	↑↓	↑ 40-65%
Choice of crops	***	↓	↓ 5-60%
Food demands and human diet	***	↑↓	n/a
Use of degraded land	***	↑↓	↑ ca. 30-45%
Competition for water	***	↓	↓ 15-25%
Use of agricultural/forestry by-products	**	↑↓	n/a
Proceted area expansion	**	↓	↓10-25%
Water use efficiency	**	↑	n/a
Climate change	**	↑↓	n/a
Alternative protein chains	**	↑	n/a
Demand for biomaterials	*	↑↓	n/a
GHG balances of biomass chains	*	↑↓	n/a
<i>Demand potential of biomass</i>		<i>demand as estimated in recent studies</i>	<i>biomass supply as estimated in TIMER</i>
Bio-energy demand versus supply	**	↑↓	↓ 80-85%
Cost of biomass supply	**	↑↓	n/a
Learning in energy conversion	**	↑↓	n/a
Market mechanism food-feed-fuel	**	↑↓	n/a

Importance of the issues on the range of estimated biomass potentials: \*\*\*- large, \*\* - medium, \* – small  
 Impact on biomass potentials: potentials as estimated in recent studies would: ↑ - increase, ↓ - decrease, ↑↓ increase or decrease – if this aspect would be taken into account.

N/a: no quantitative analysis has been carried out in this study

\* See Section 4.2 for a more detailed description of underlying results of this Table

Dornburg et al. 2008

# Method

---

- ▶ 1. Analyze FAOSTAT Food Supply for all countries 1961-2007
- ▶ 2. Aggregate FAOSTAT data into GCAM regions and categories
- ▶ 3. Develop Scenarios
- ▶ 4. Calibrate GCAM to match historic FAO data
  - ▶ adjust animal efficiencies and non-food demand of vegetal products
- ▶ 5. Change income elasticities for each GCAM food category to achieve desired scenario by 2095 (linear approach)





## Part II.

# Historical Trends in Food Consumption

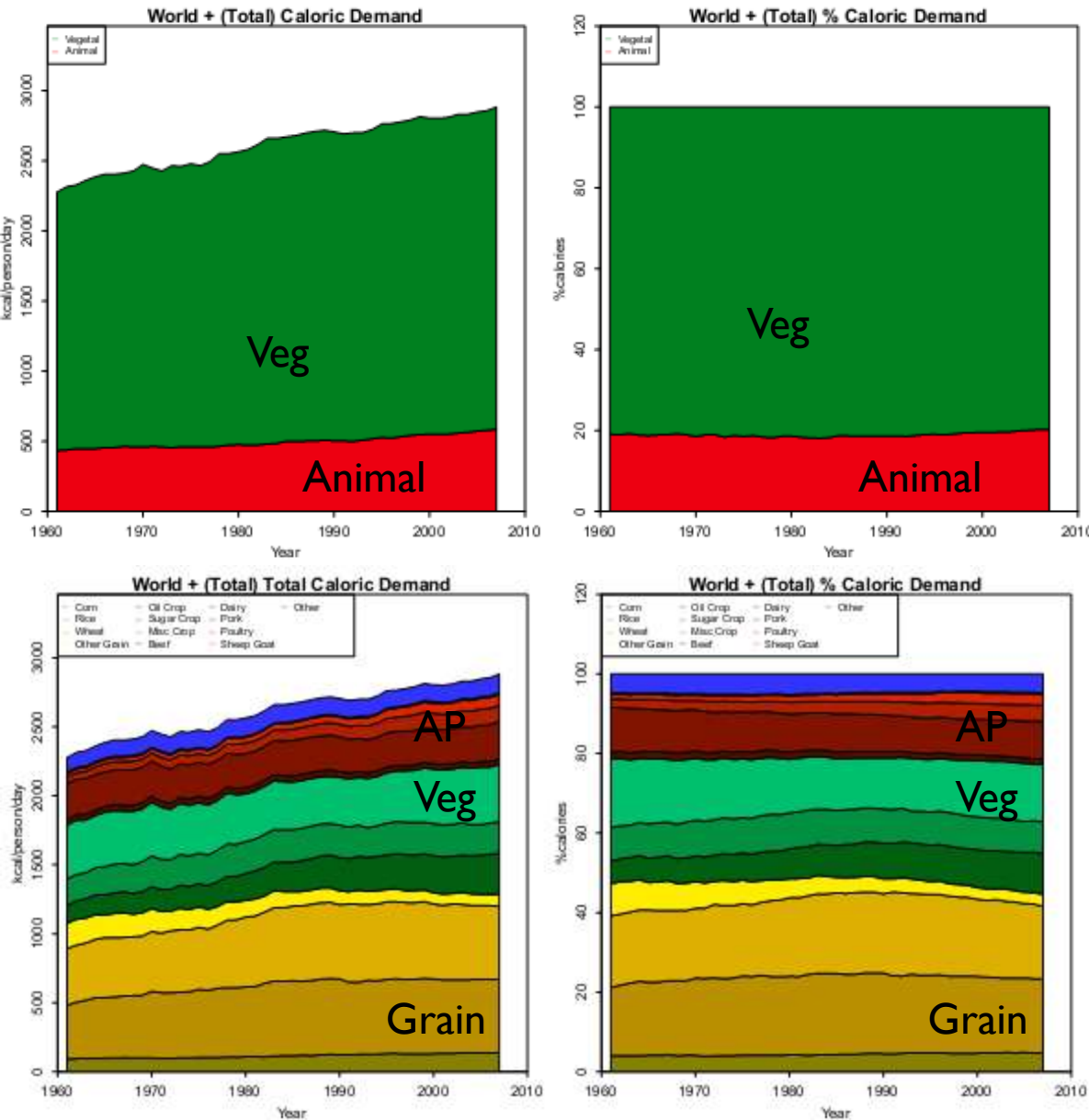
---



# Global Trends

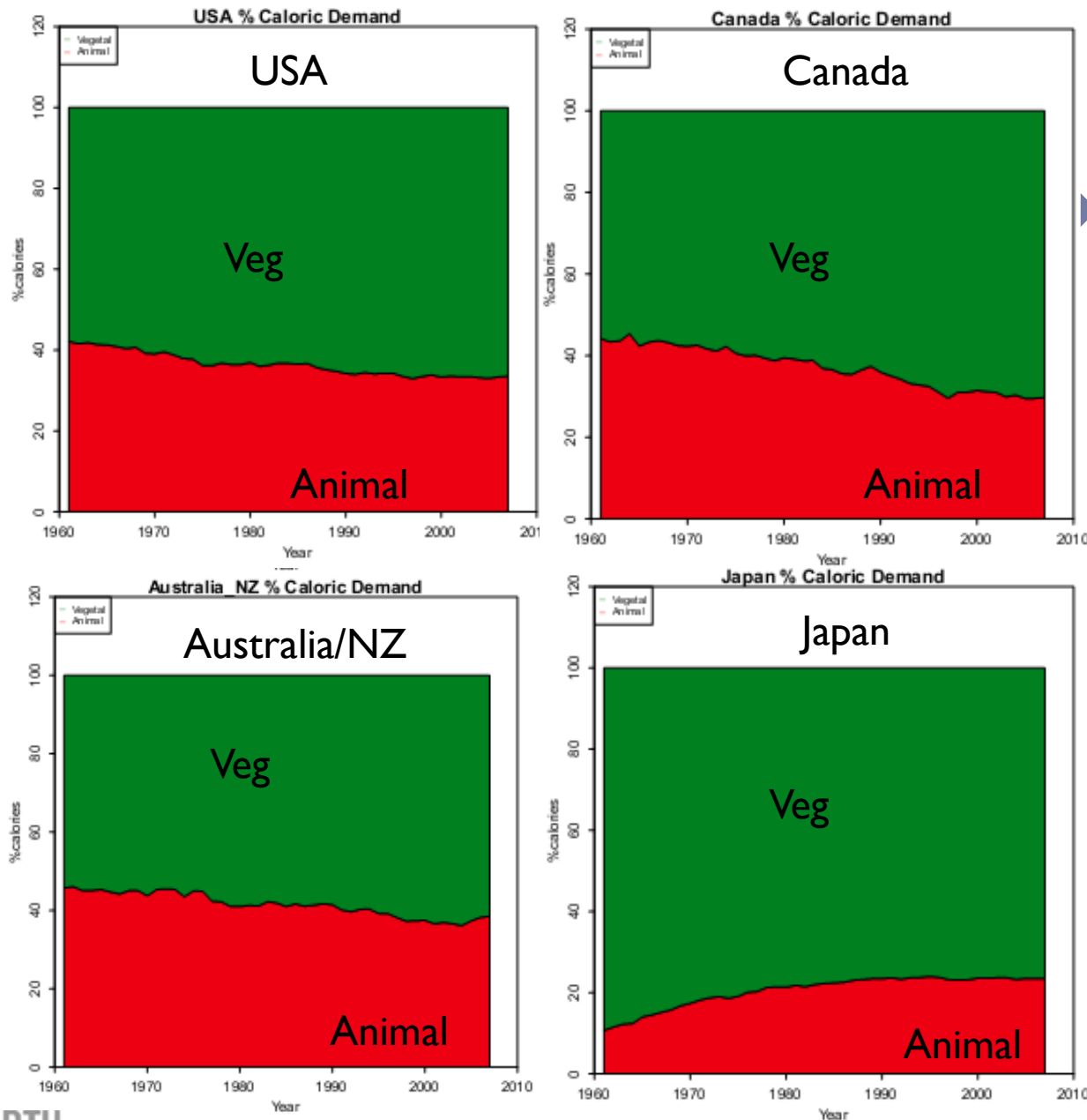
- ▶ Have not changed much in the last 50 years
- ▶ Overall food demand has increased
- ▶ Animal product demand has remained relatively constant

raw data source: FAOSTAT



# Developed Regions

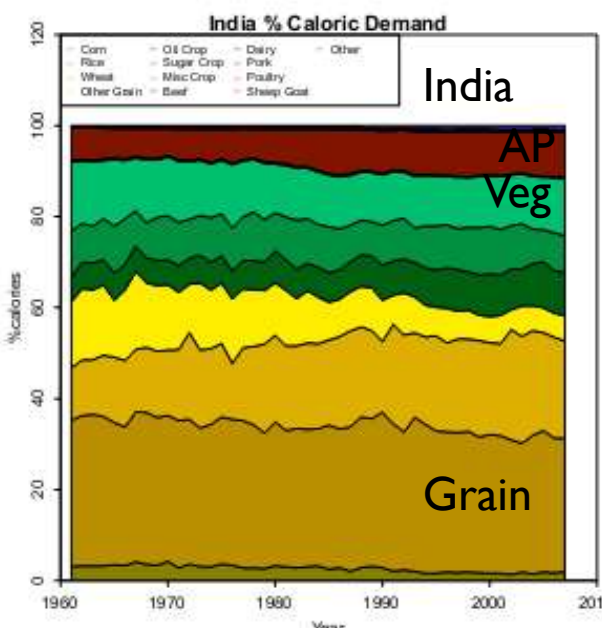
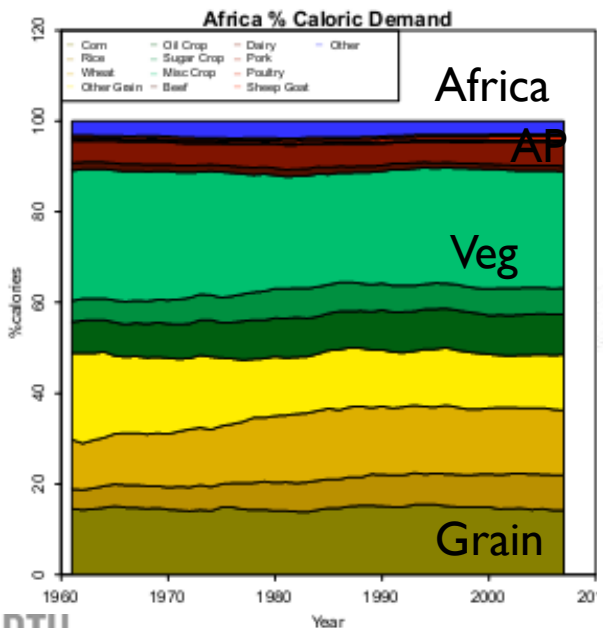
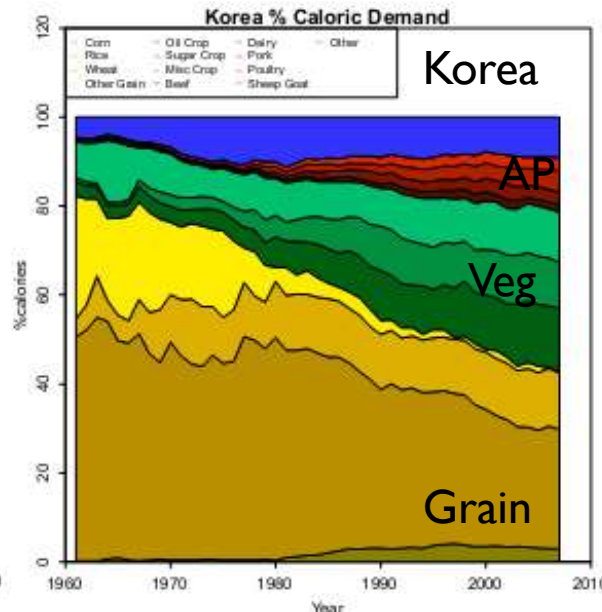
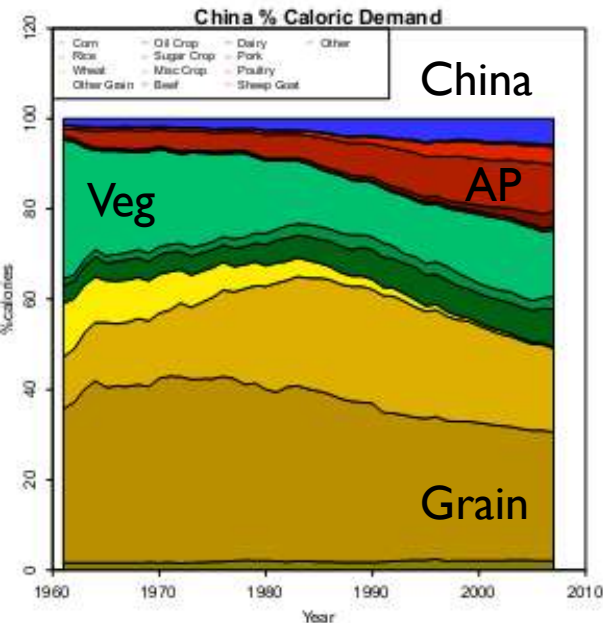
- ▶ Animal product demand tends to decrease as a proportion of diet



raw data source: FAOSTAT

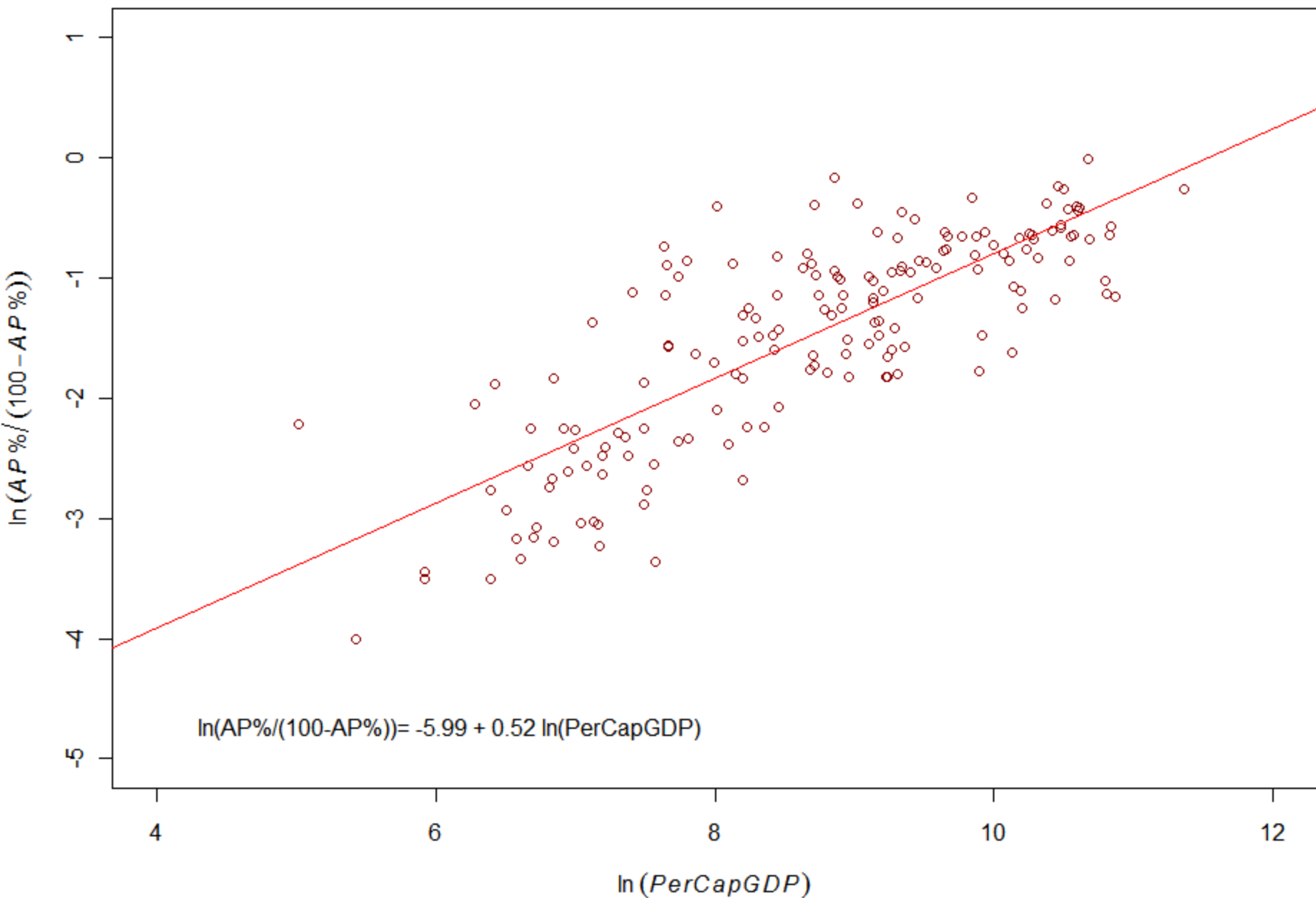
# Developing Regions

- ▶ Animal product demand tends to increase as a proportion of diet; but not always (e.g., Africa, India)
- ▶ Vegetable demand also increases

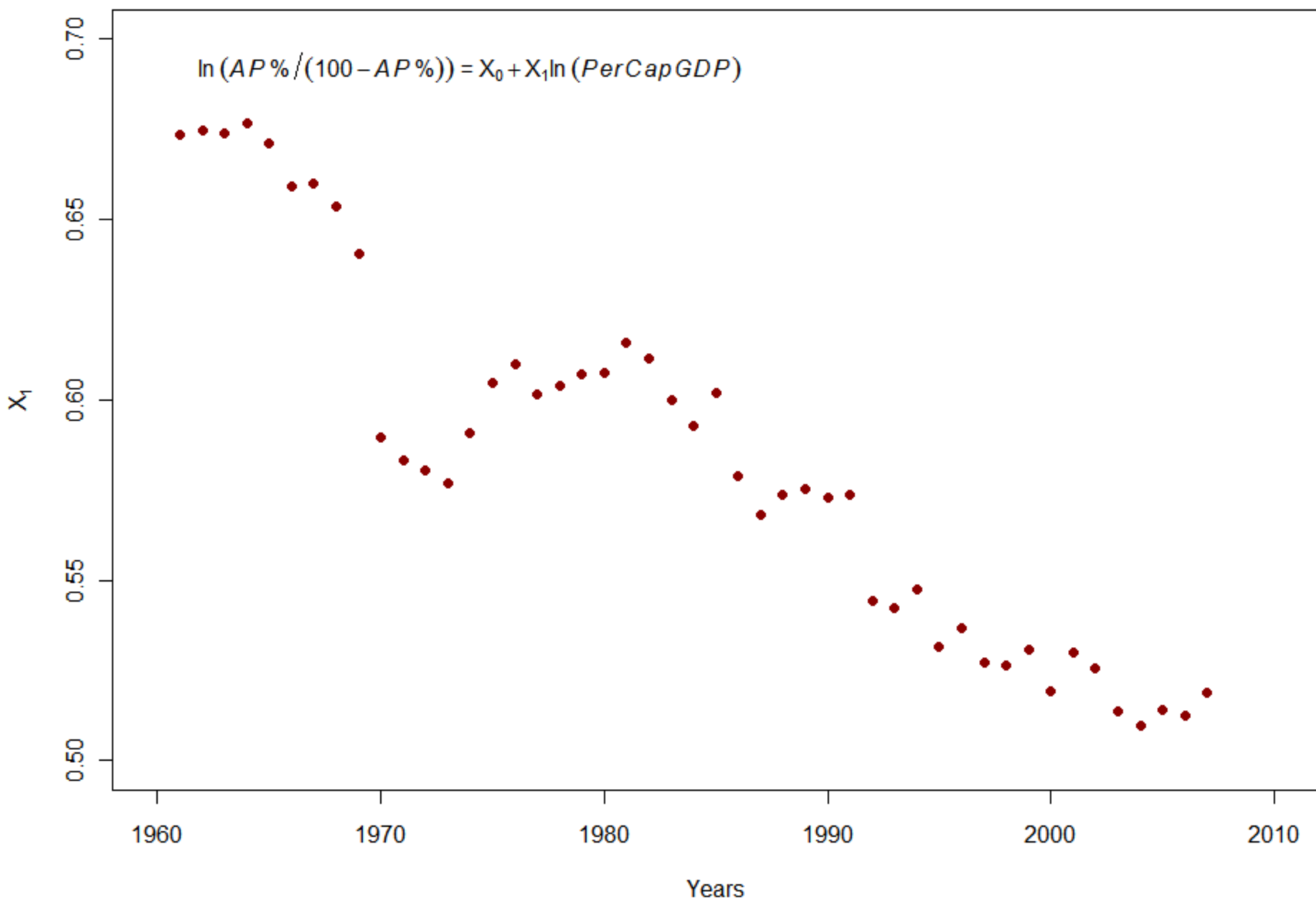


raw data source: FAOSTAT

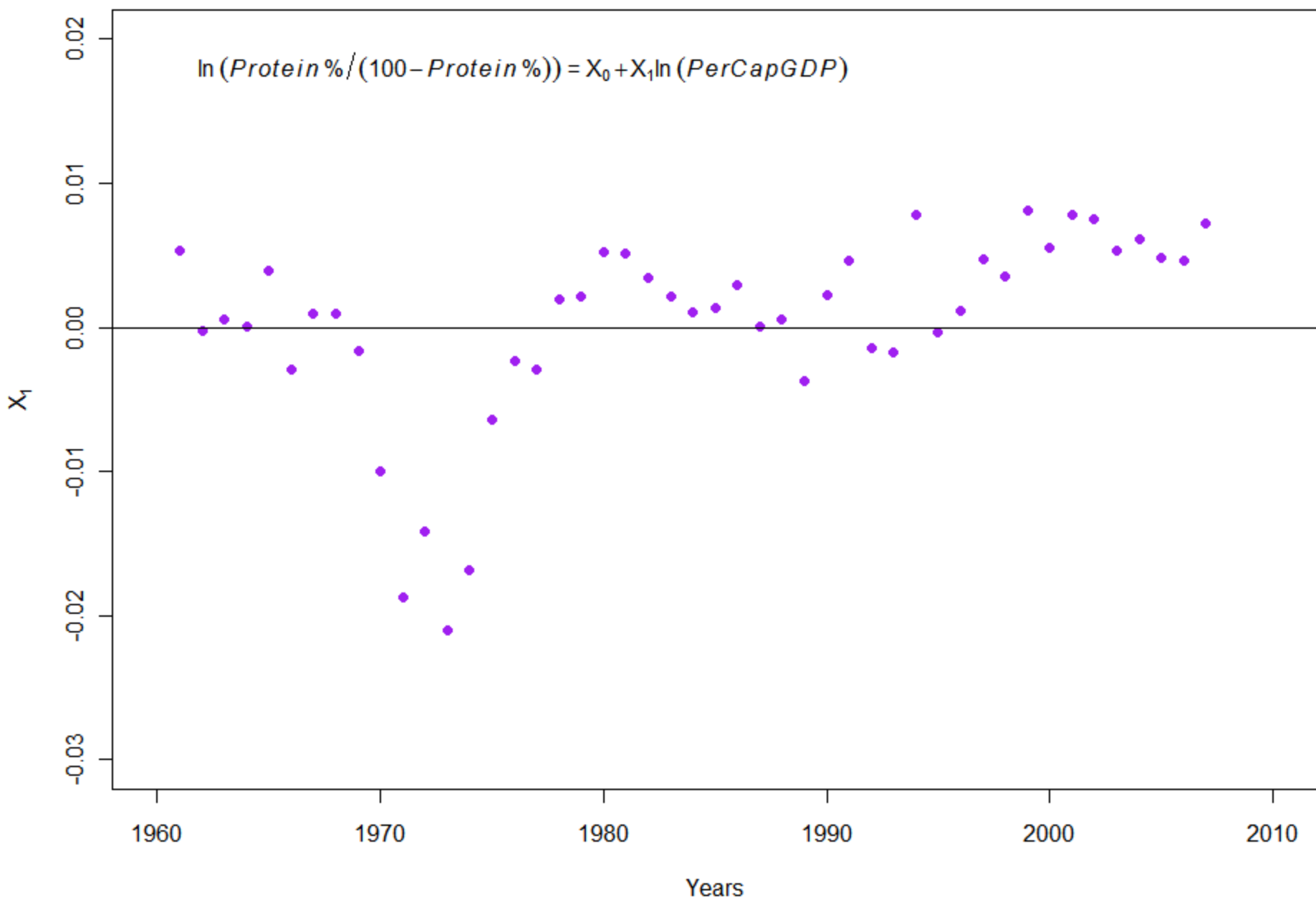
**Animal Products % (by calories) vs. Income, 2007**



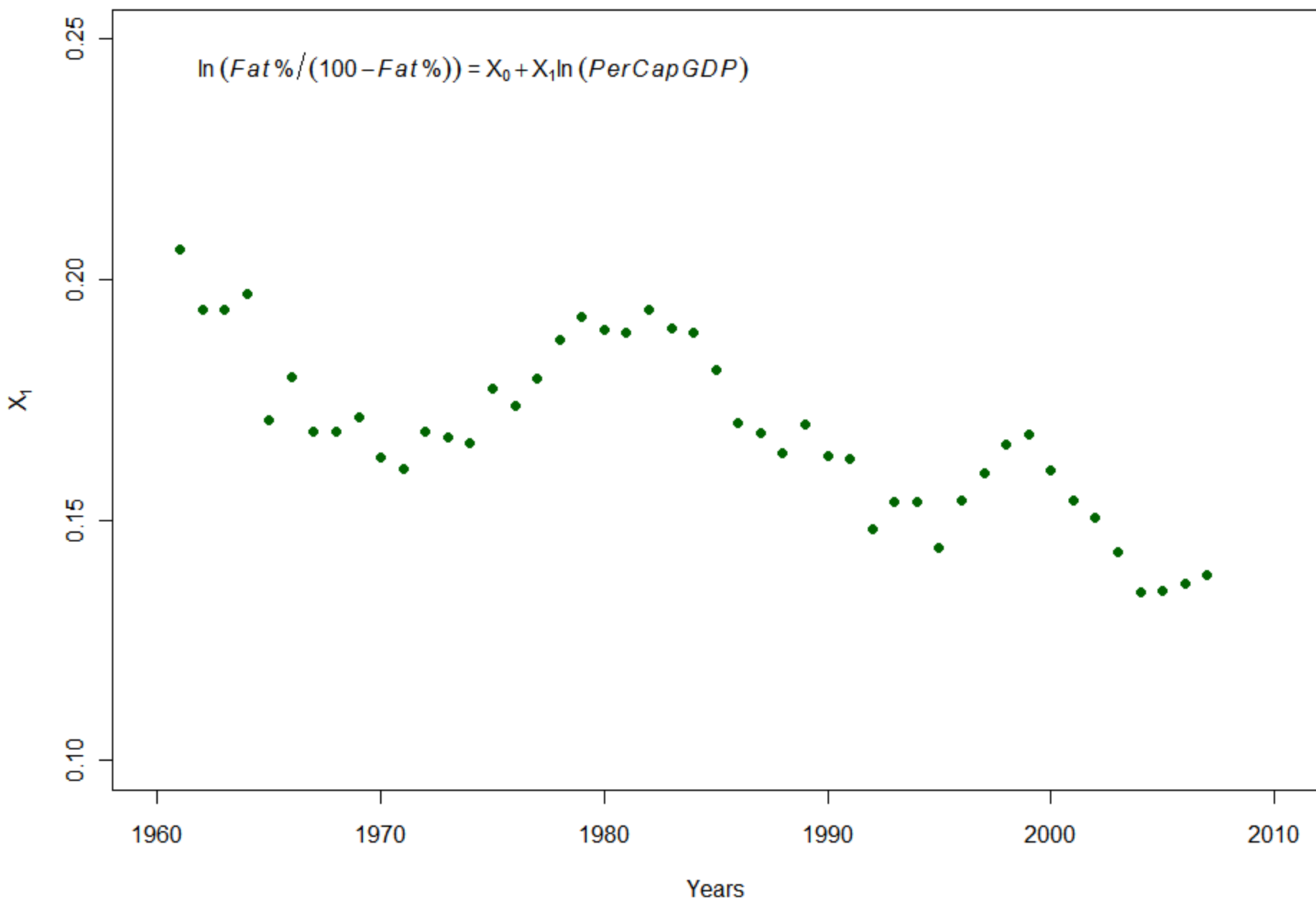
**Animal Product % of Diet (by calories) vs. Wealth  
Slope by Year**



**Total Protein % of Diet (by mass) vs. Wealth**  
**Slope by Year**



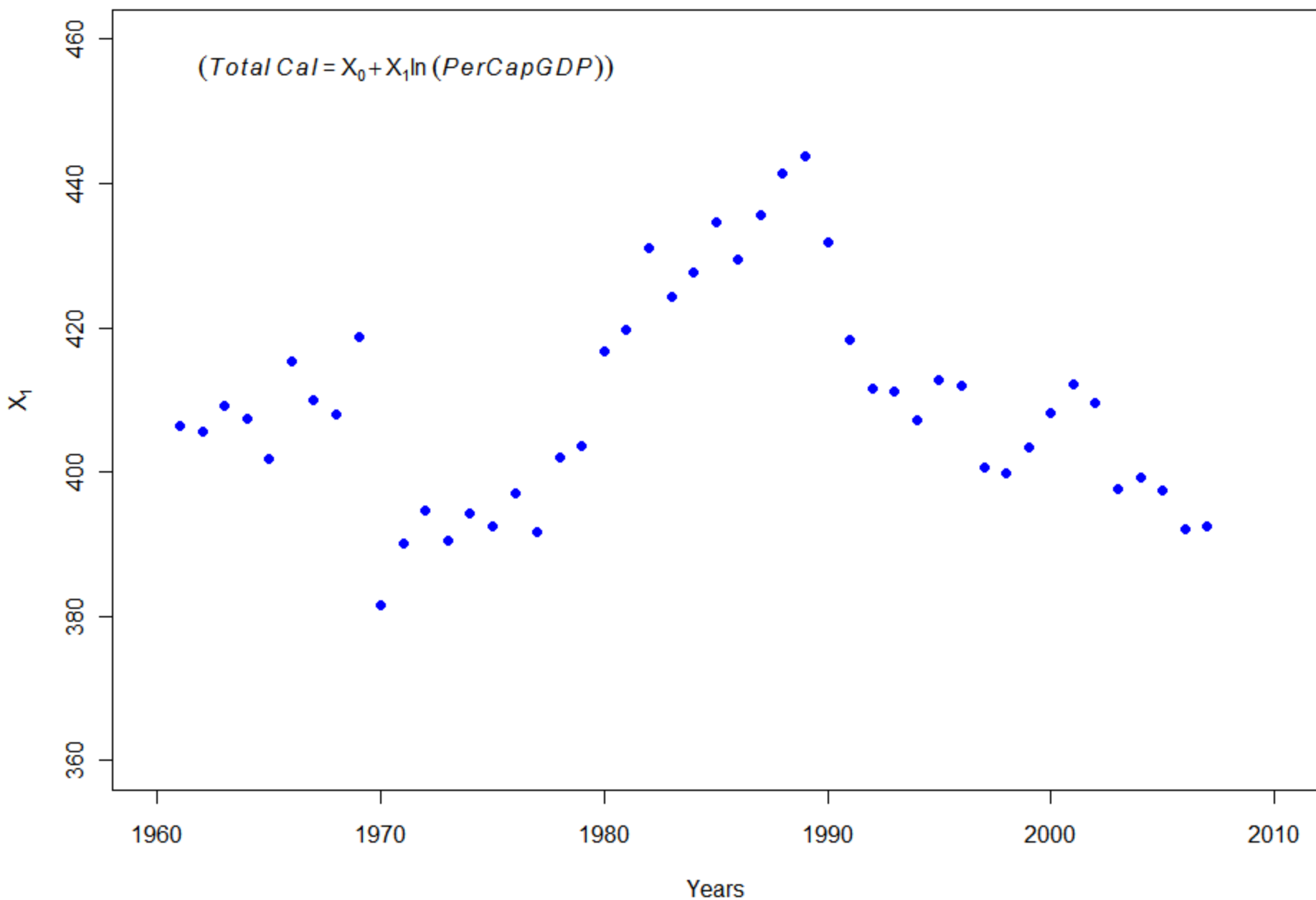
**Total Fat % of Diet (by mass) vs. Wealth**  
**Slope by Year**





# Total Caloric Demand vs. Wealth

## Slope by Year



# Summary of Historic Trends

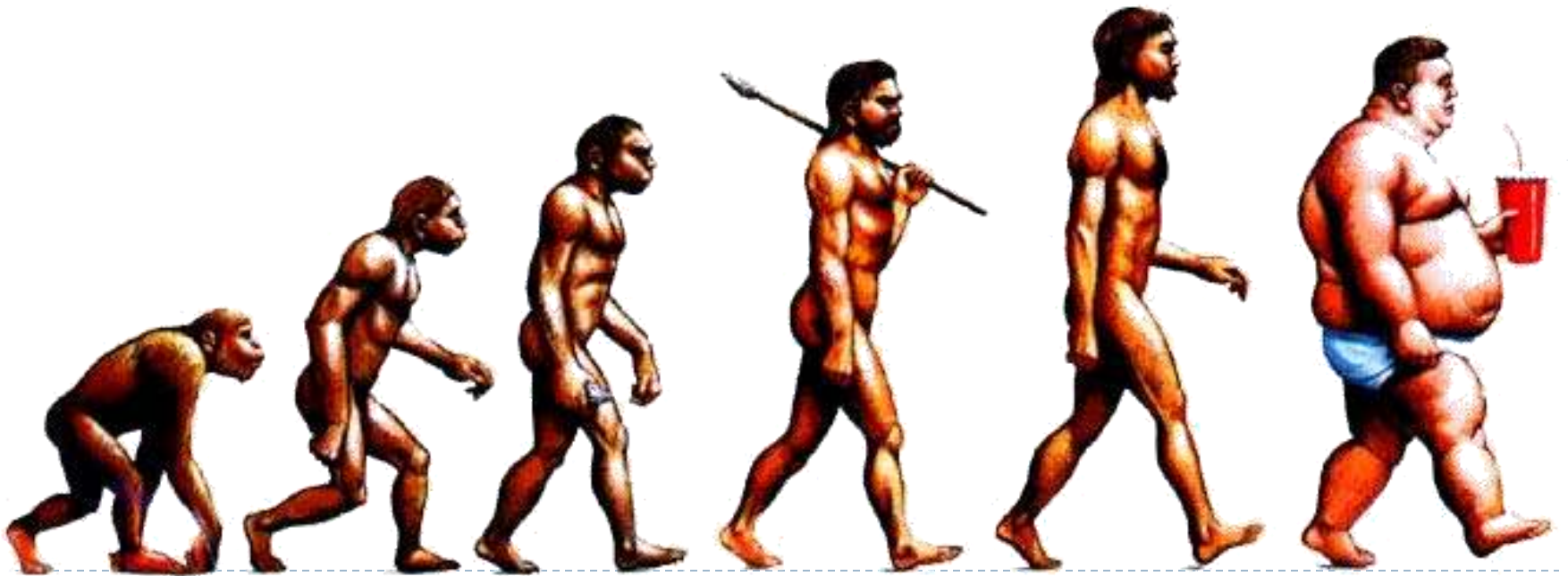
---

- ▶ Developed countries are reducing or plateau-ing their animal consumption
- ▶ Developing countries are increasing animal consumption, but also vegetable consumption
- ▶ Percent of Animal Products increases with increasing wealth; but not as much as it used to
- ▶ Protein demand as % of calories has no relationship to wealth.
- ▶ Fat demand increases with increasing wealth; this relationship changes slightly over time... not as much as it used to be
- ▶ Total calorie demand increases with wealth; this relationship changes over time, but no apparent trend. We can assume that there is a maximum number of calories that can be demanded.

# Part III.

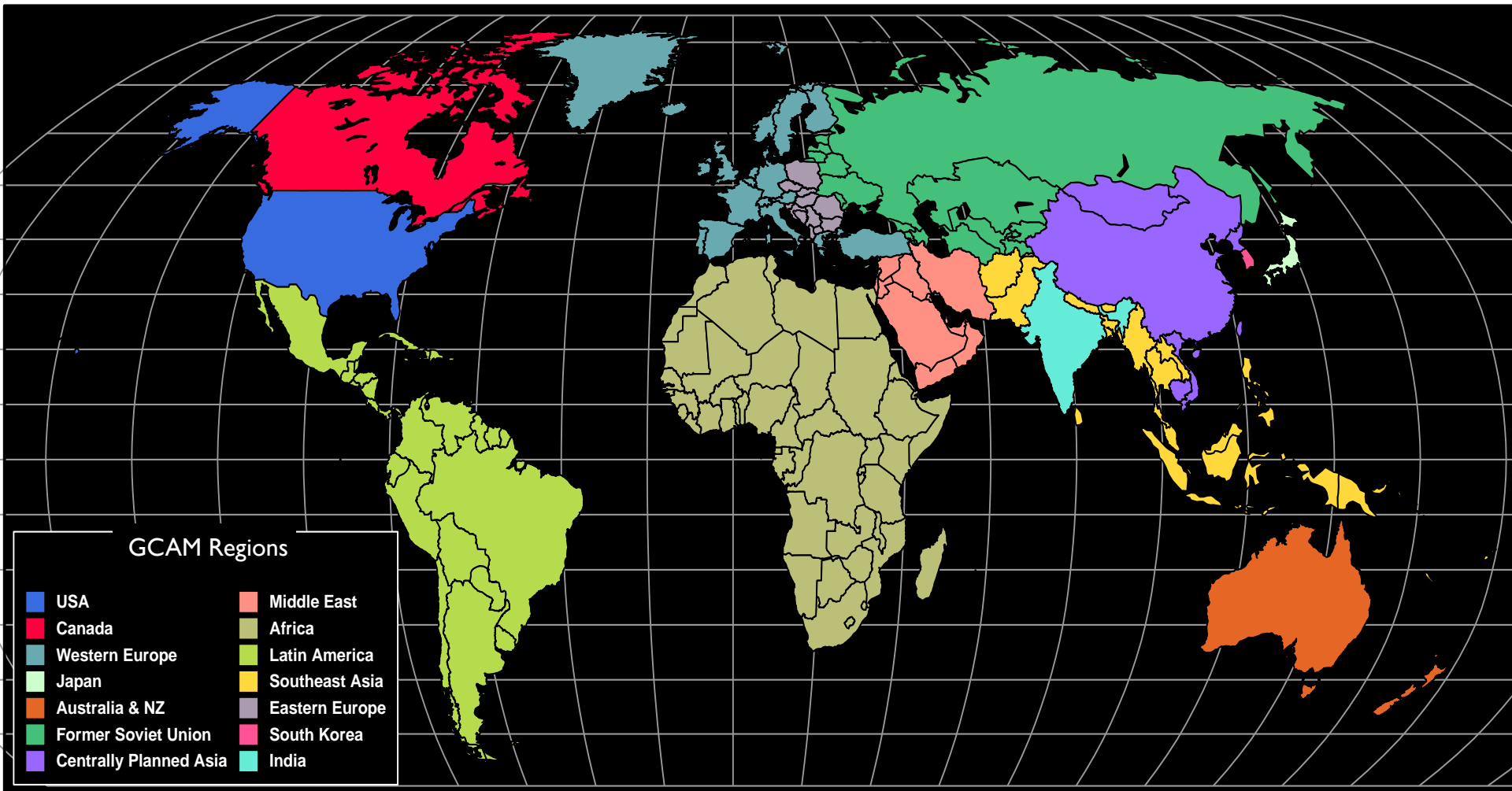
## Modeling Diets of the Future

---

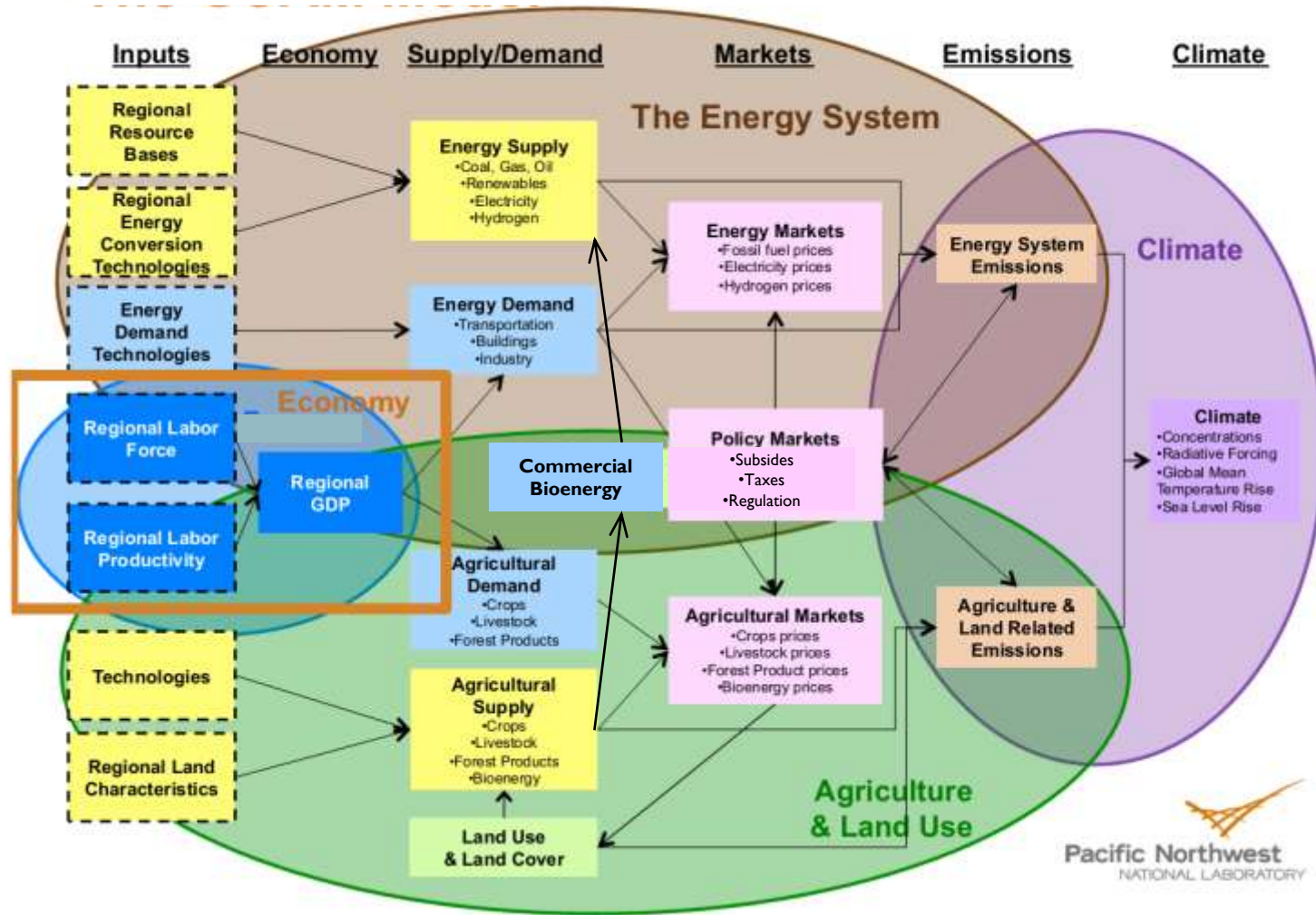


# GCAM: Global Change Assessment Model

---

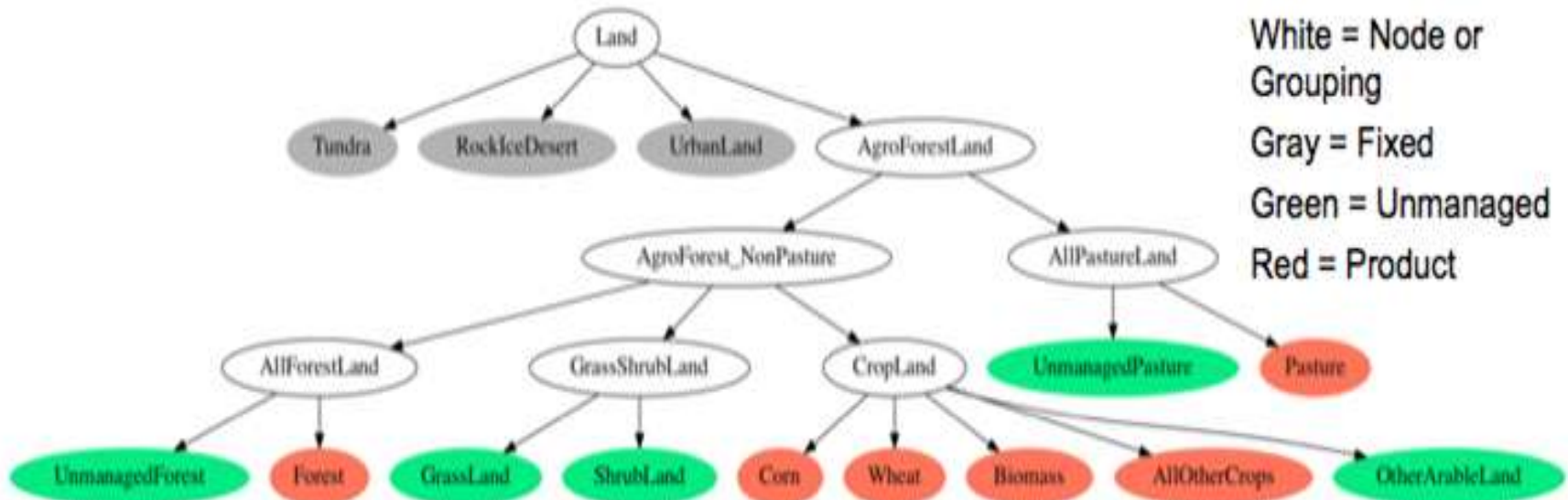


# GCAM Structure



Pacific Northwest  
NATIONAL LABORATORY

# GCAM Land Category Nesting



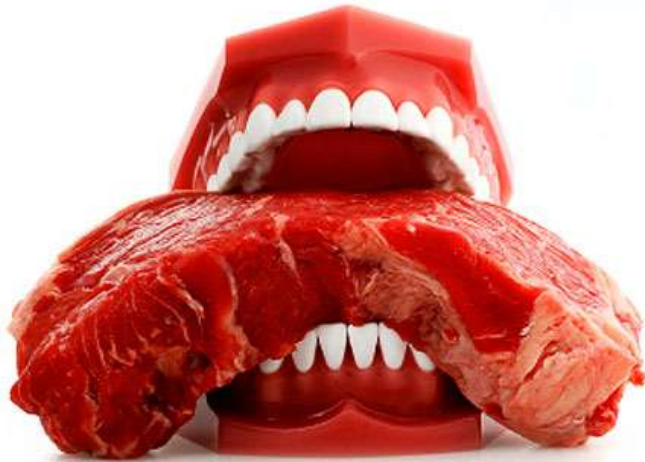
# Scenarios Explored for Future Diet

---

- ▶ 1. High Animal Products
  - ▶ Evolve to a American/Western European Diet
  - ▶ ~3500-4000 kcal/cap/day
  - ▶ ~35-40% animal products
  - ▶ small price elasticity to allow model to solve
- ▶ 2. Low Animal Products
  - ▶ Evolve to a Indian Diet
  - ▶ ~2500 kcal/cap/day
  - ▶ 10% animal products
- ▶ 3. “Healthy” diet
  - ▶ Defined by Harvard/WHO
  - ▶ ~2800 kcal/cap/day
  - ▶ specific dietary consumption recommendations (high fruit and vegetable)
  - ▶ fat and protein targets
- ▶ 4. Extrapolated trend
  - ▶ Extrapolation of regional trends with relatively higher meat consumption
  - ▶ Per capita vegetal consumption unchanged



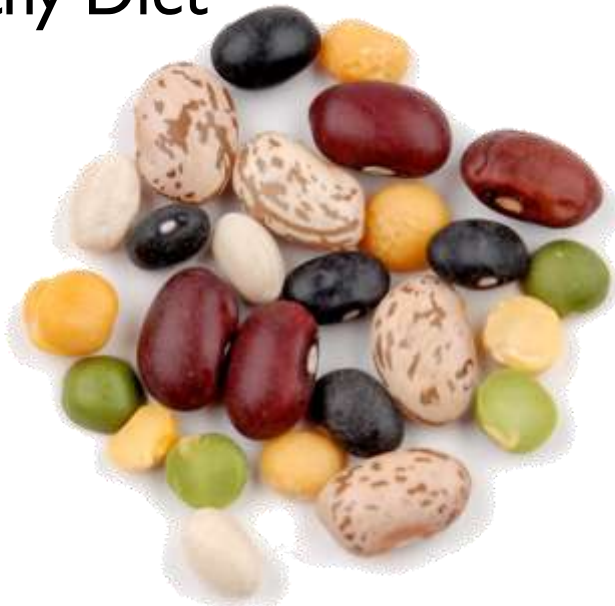
High Animal Products



Low Animal Products



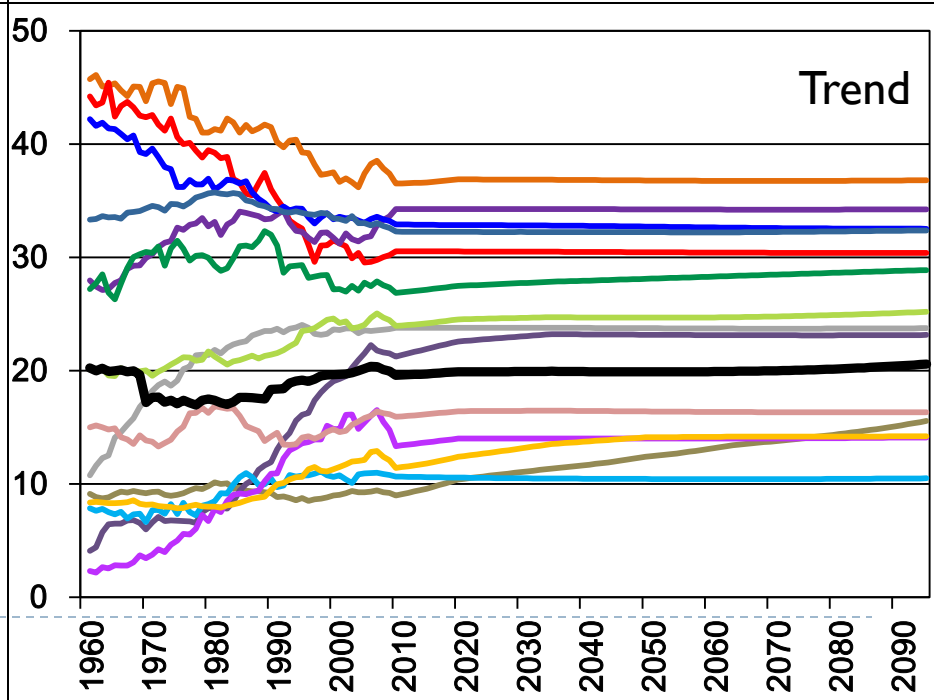
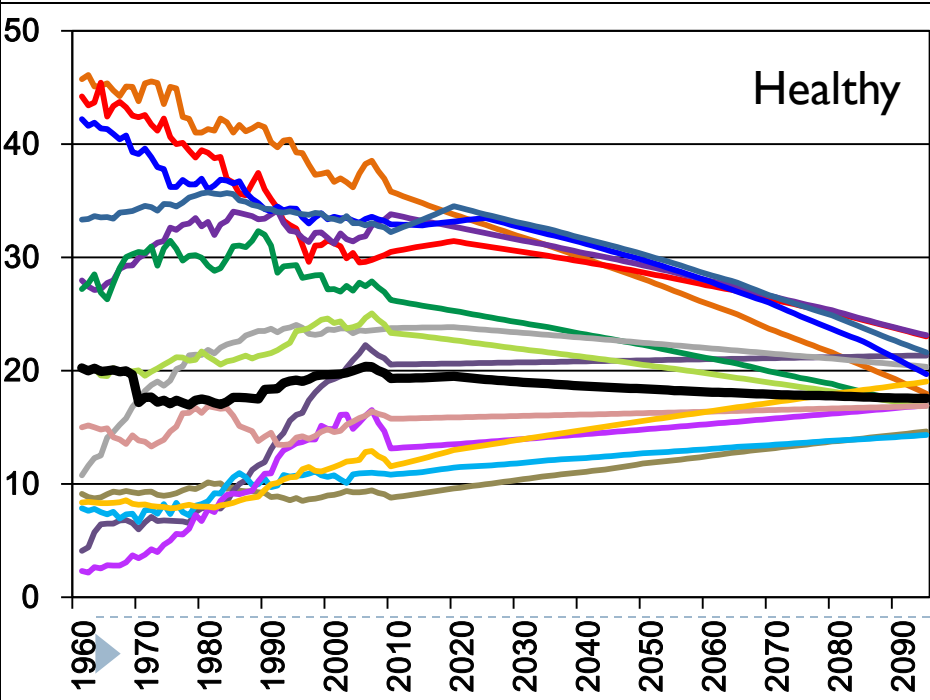
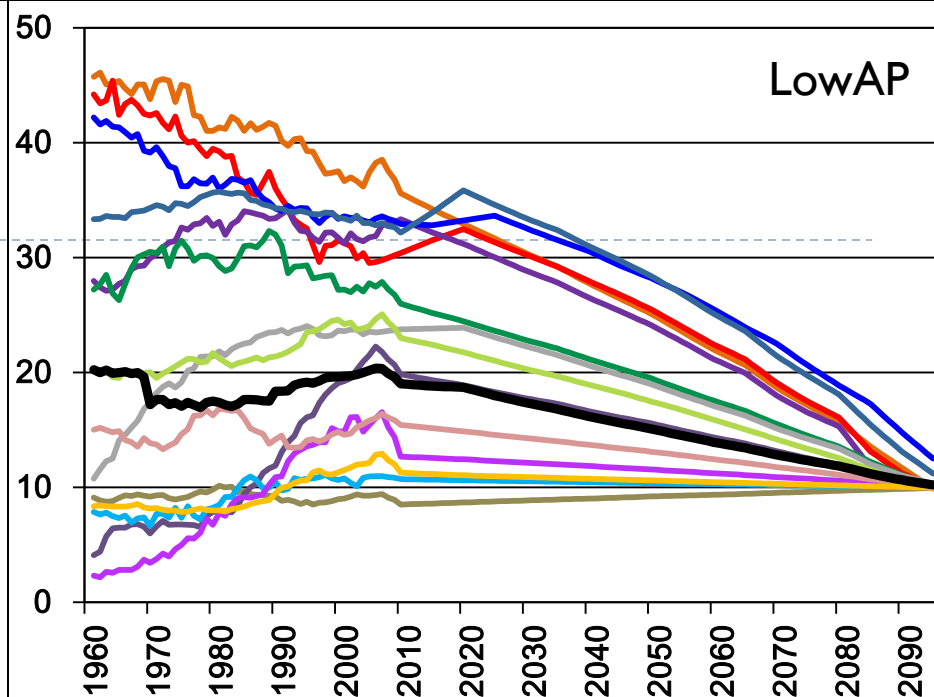
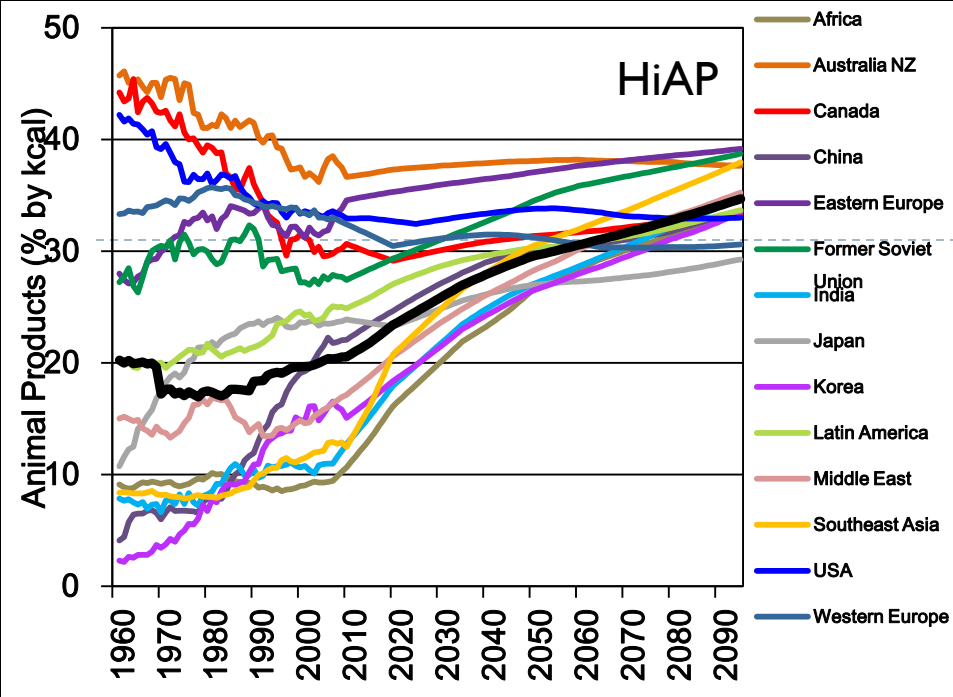
Healthy Diet

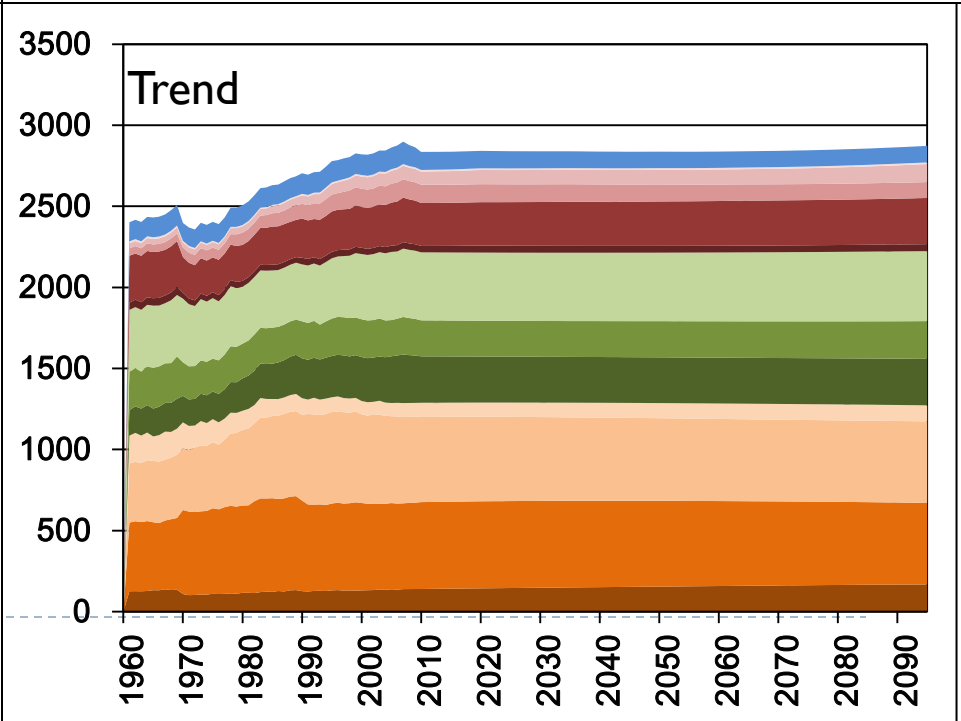
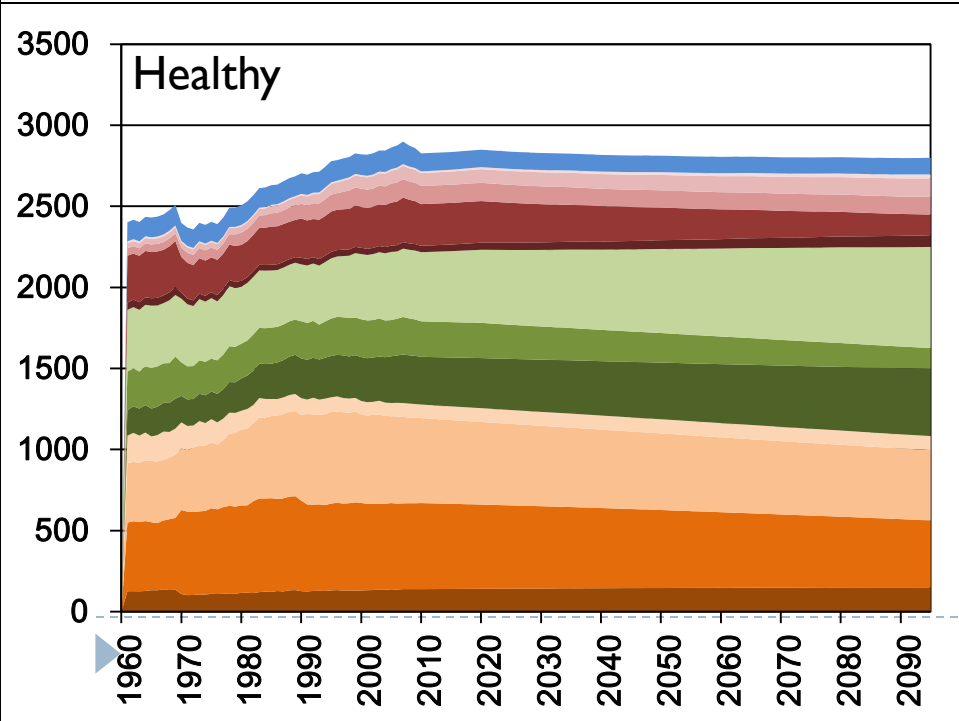
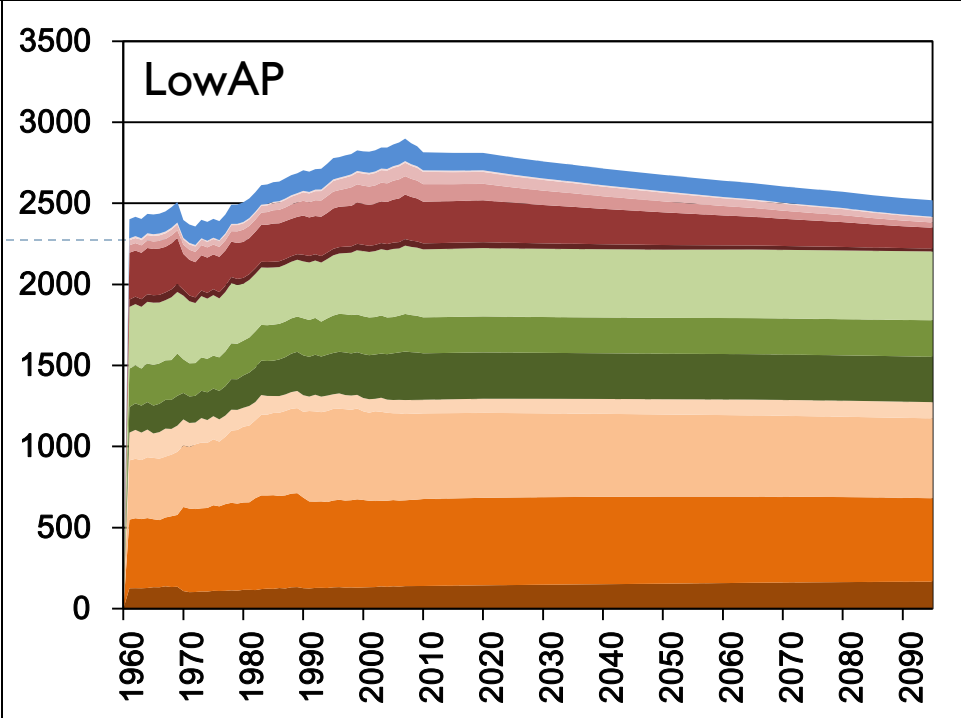
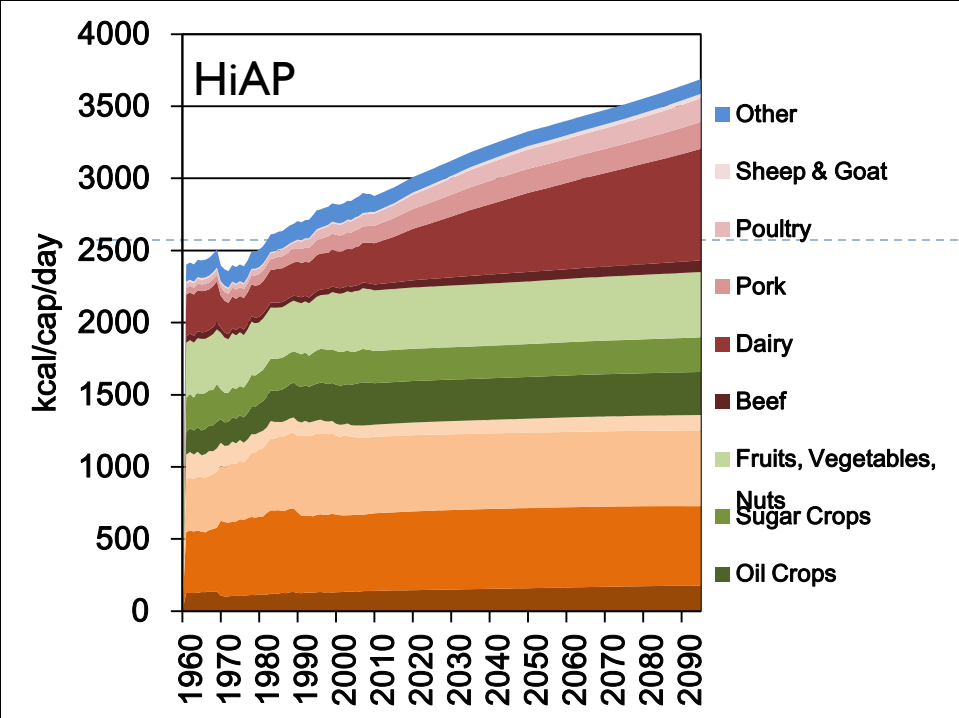


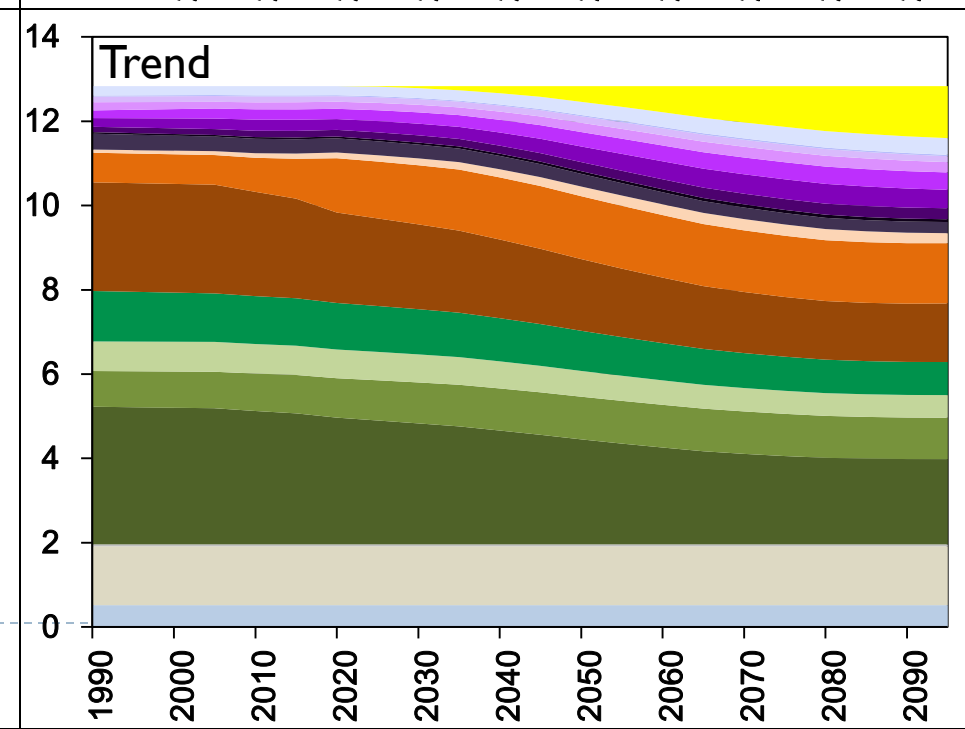
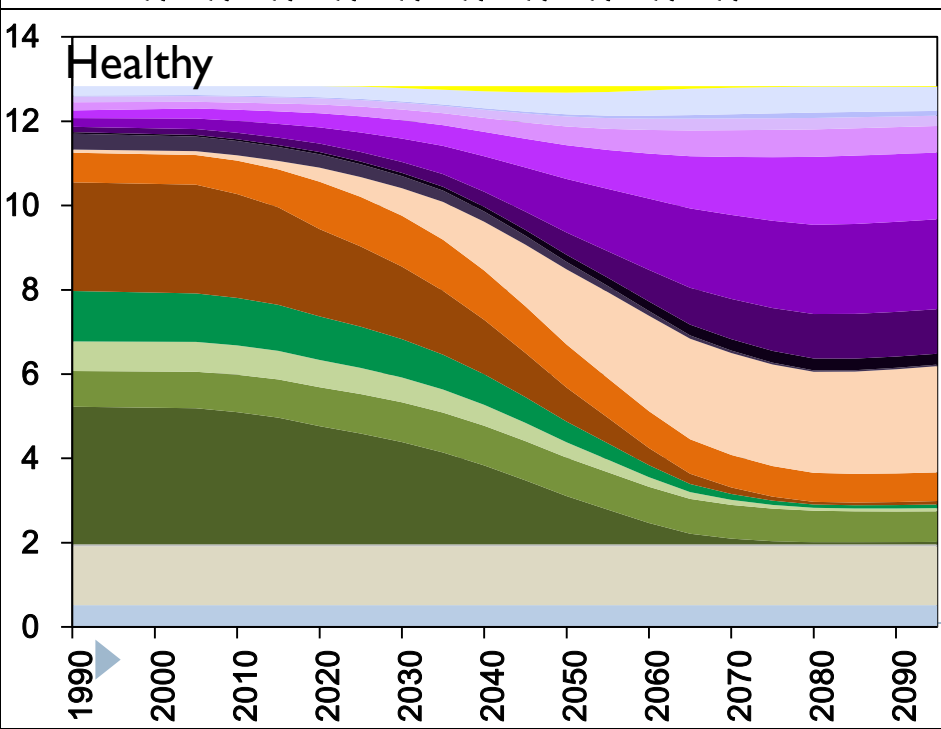
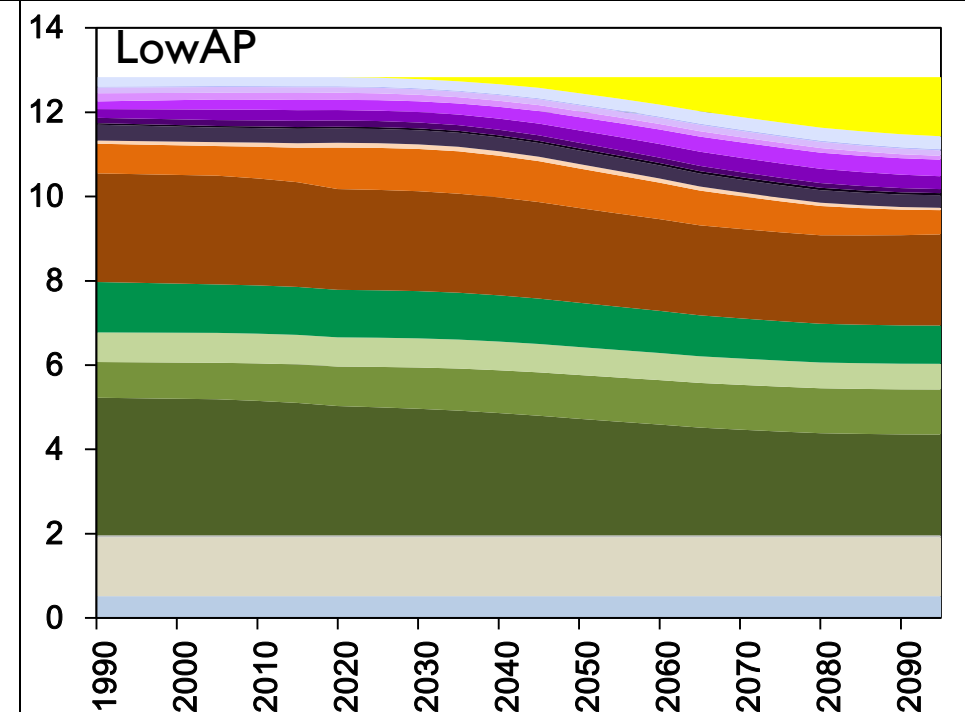
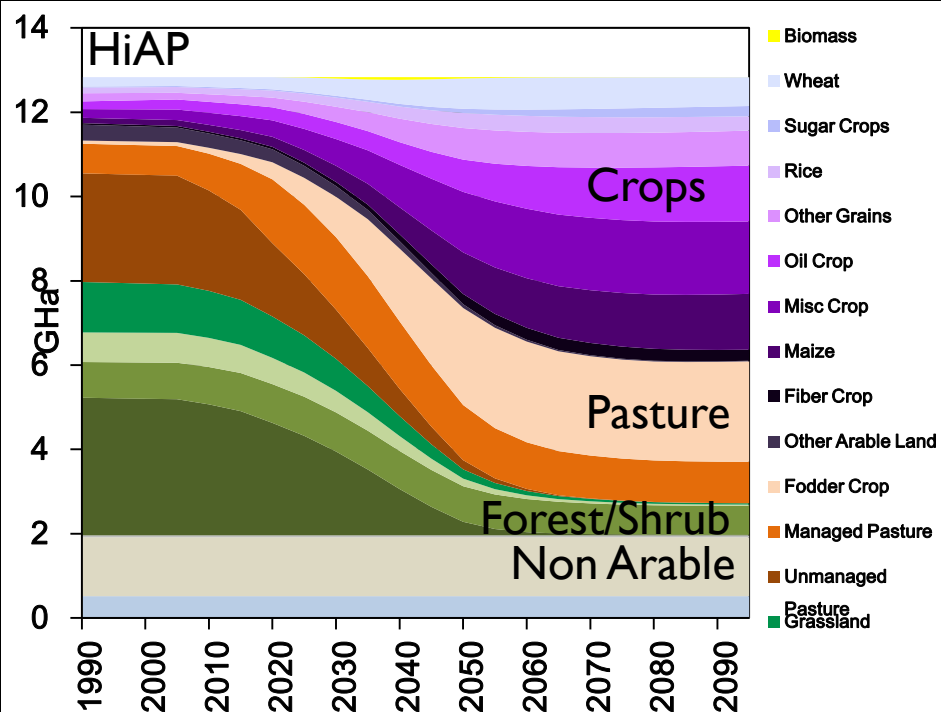
Extrapolated Trend

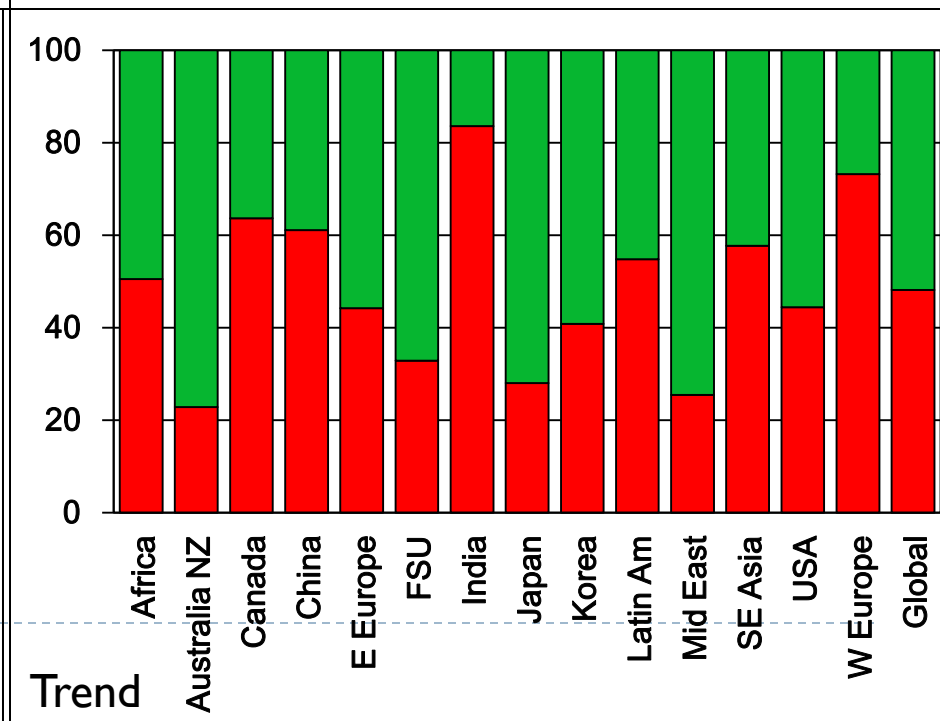
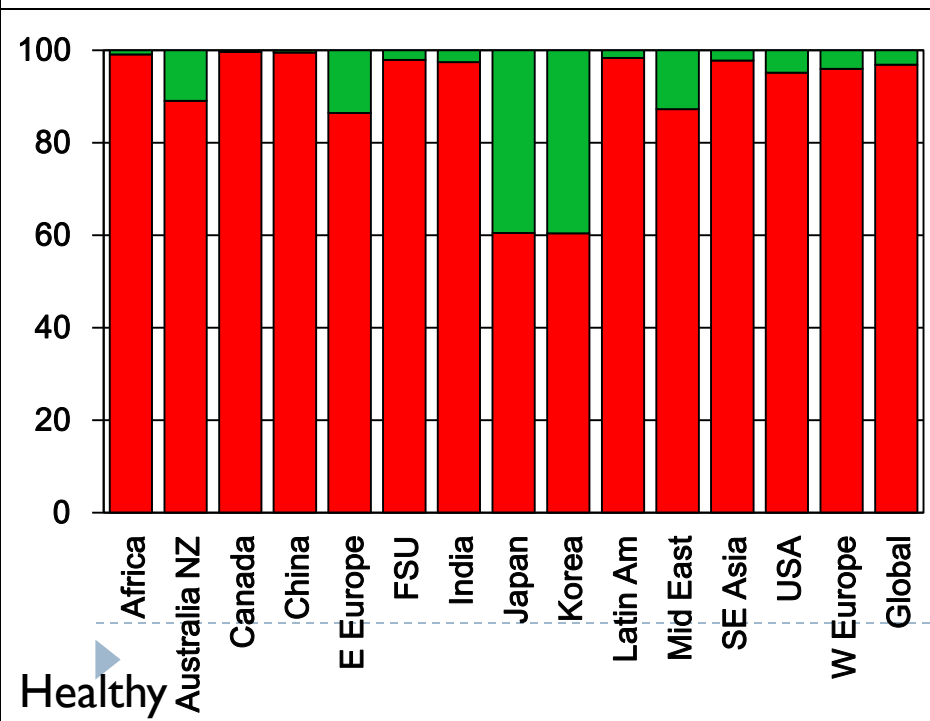
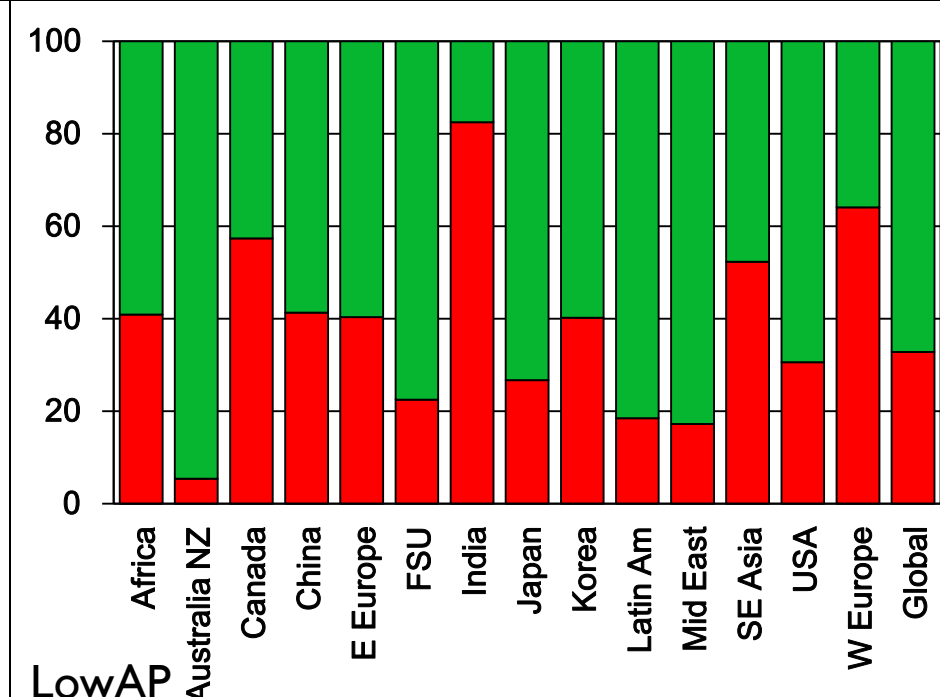
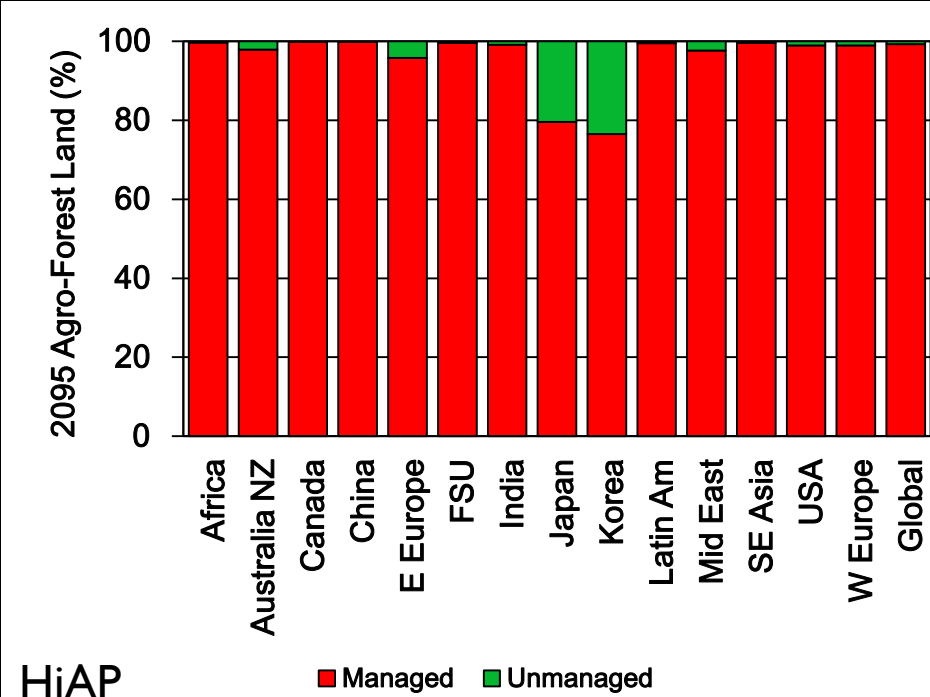


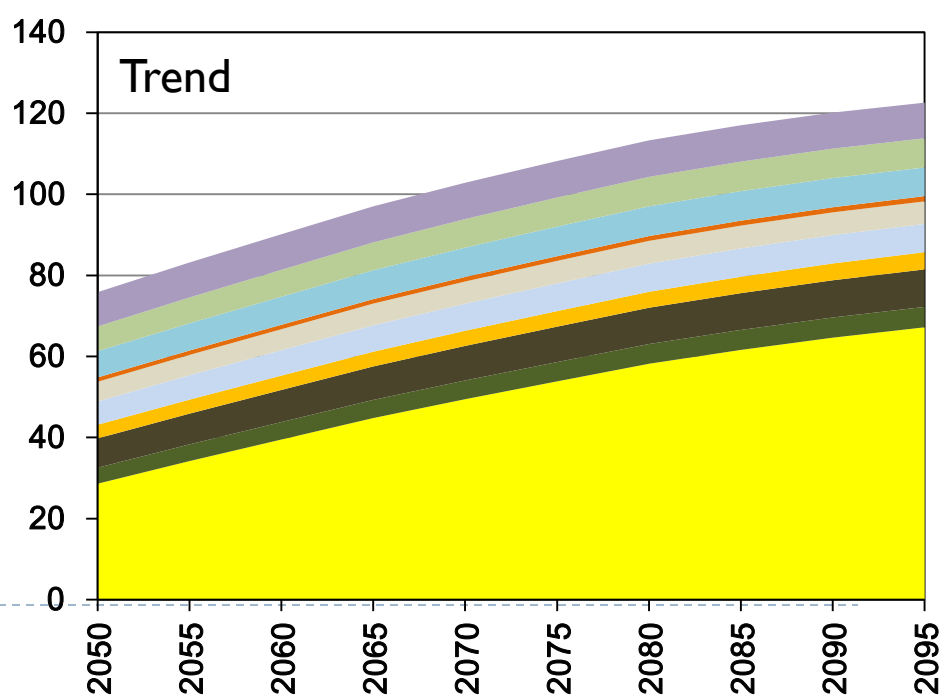
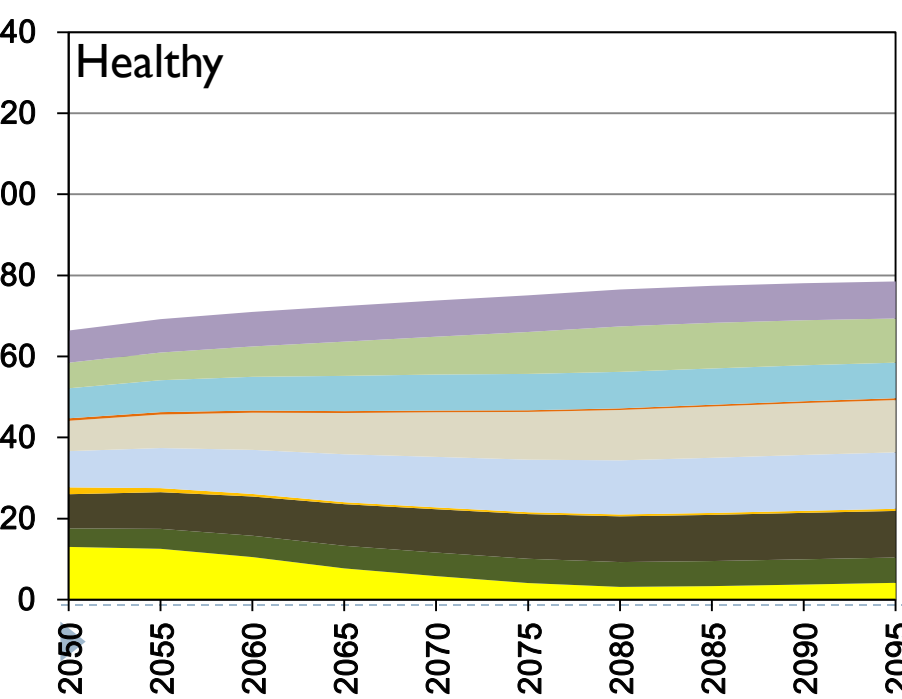
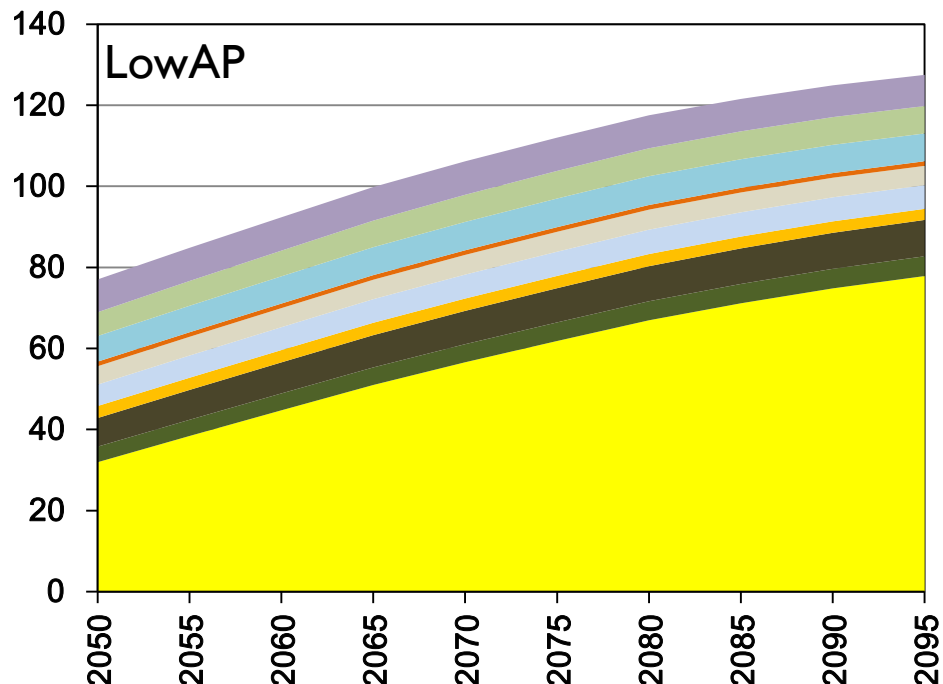
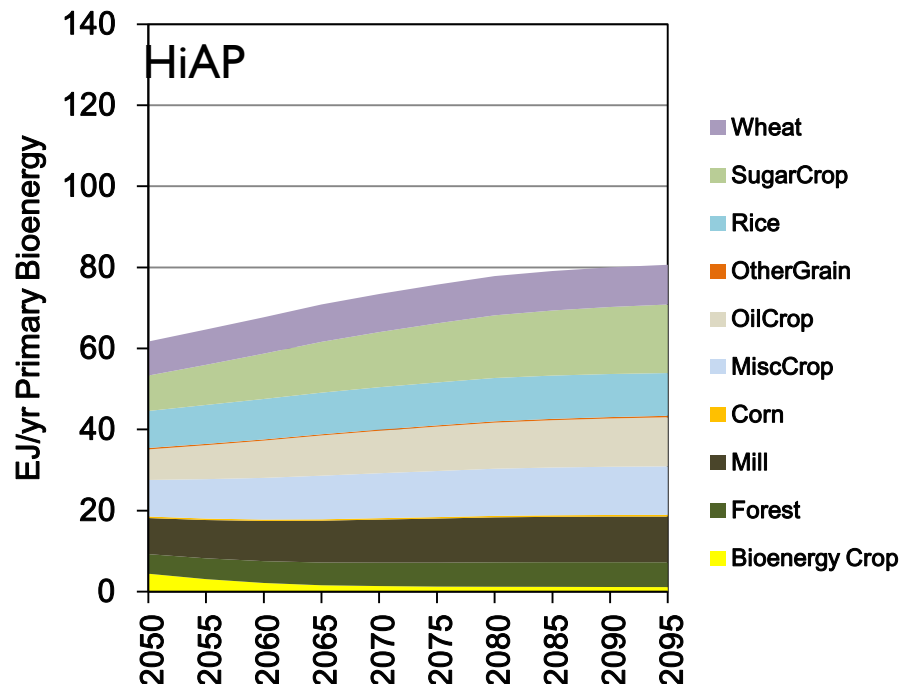


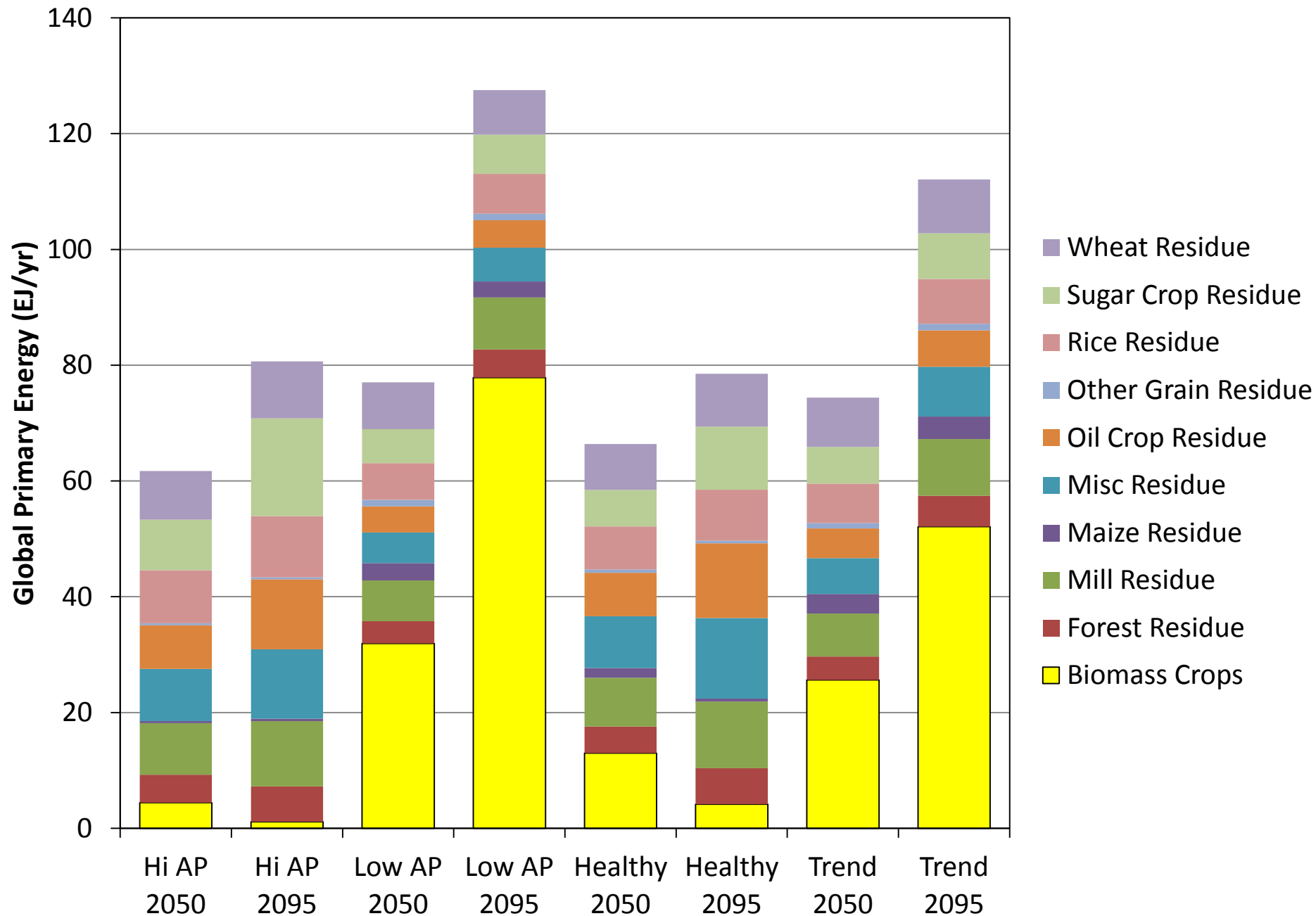


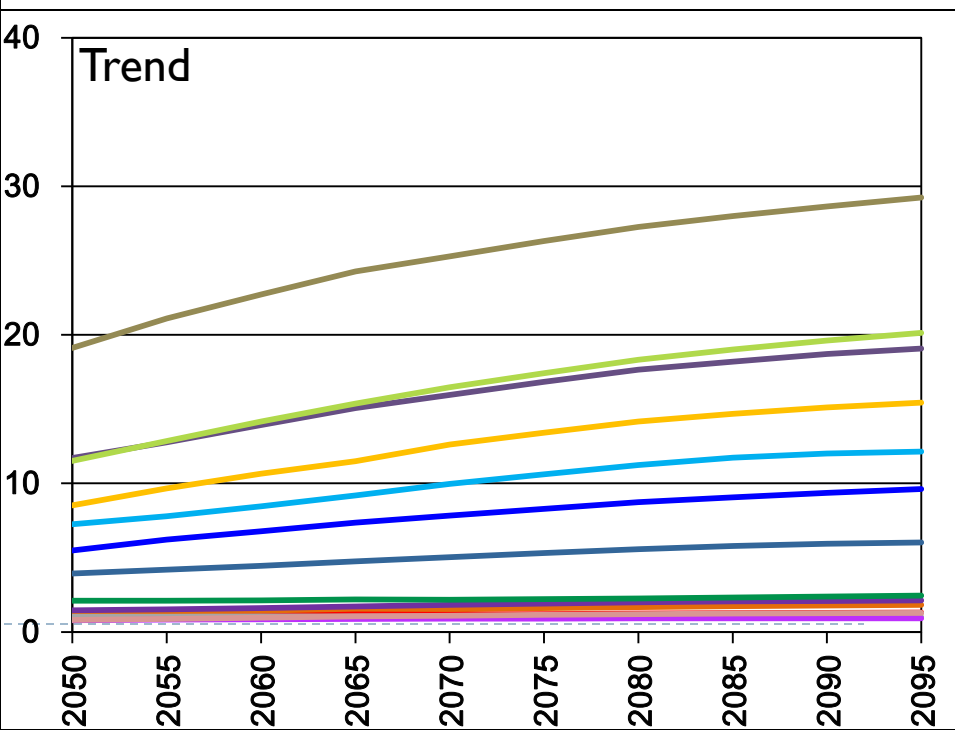
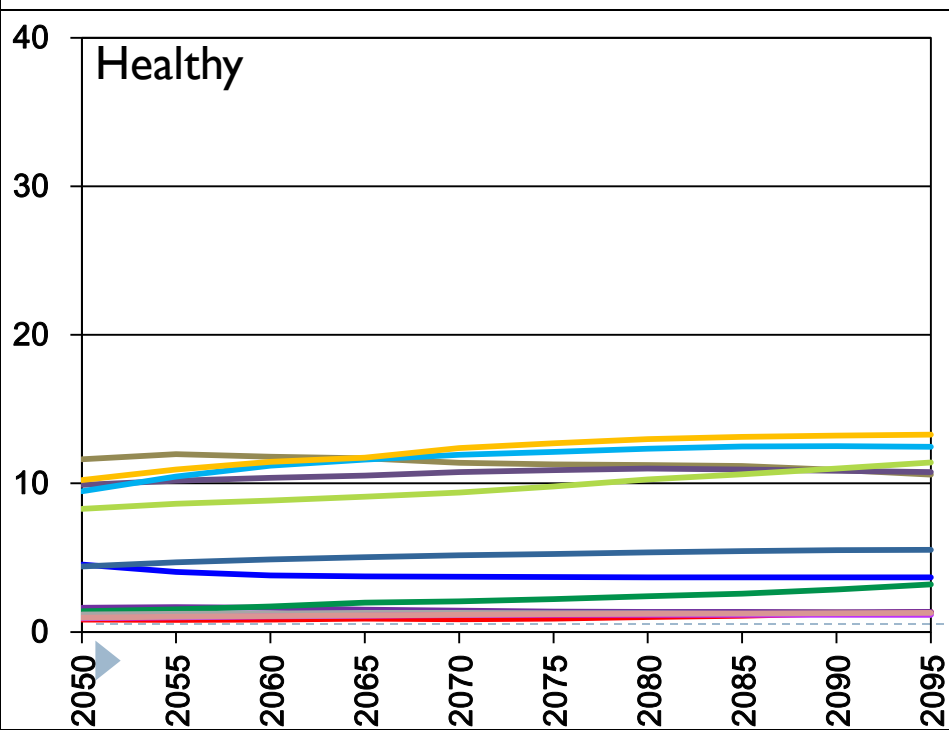
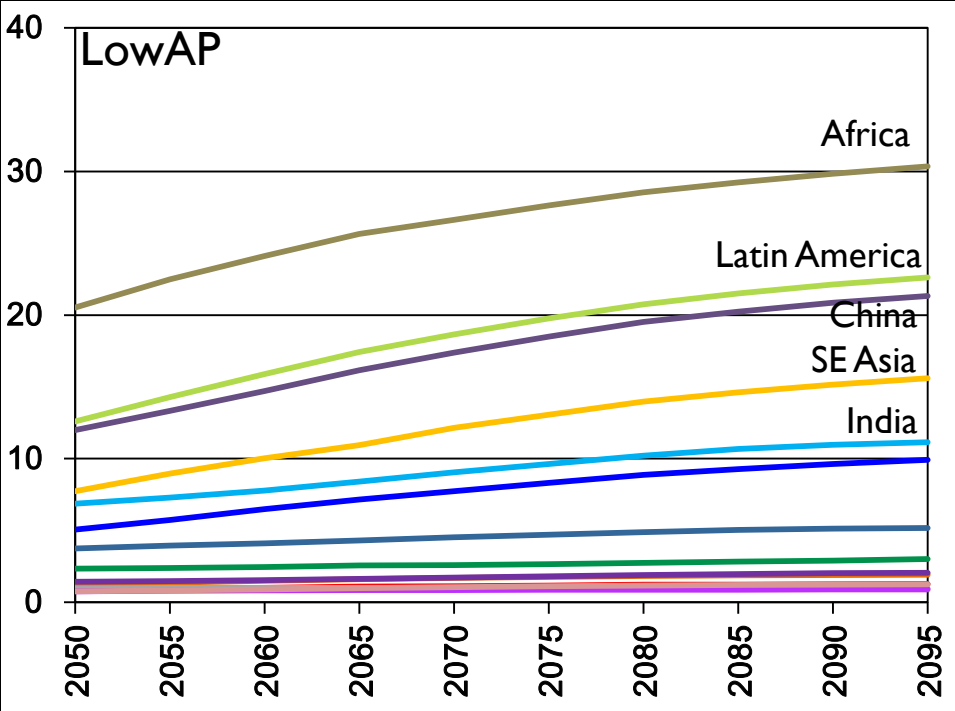
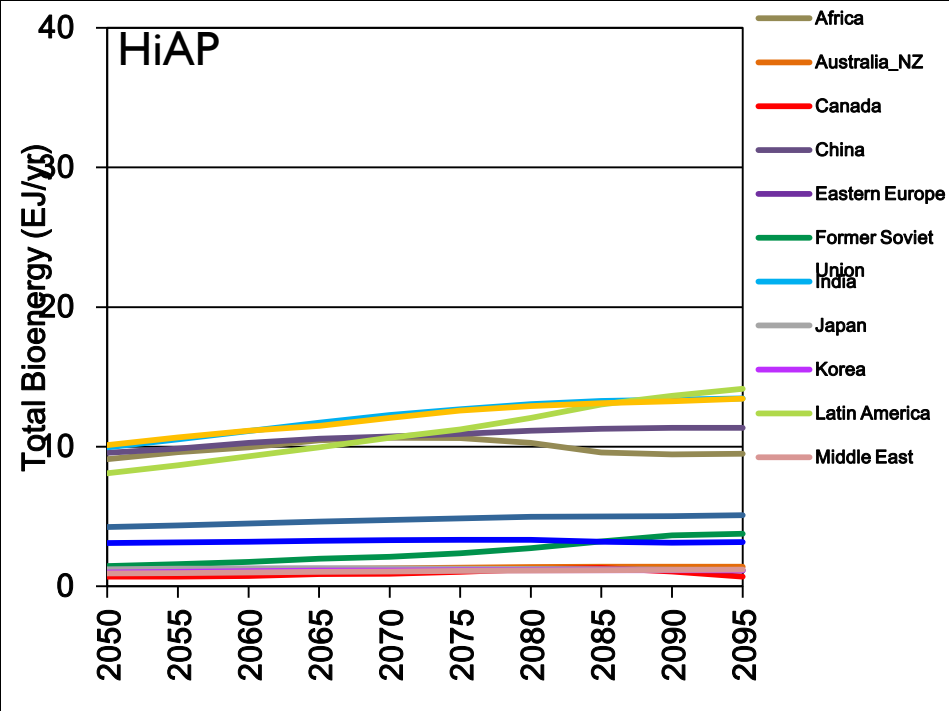








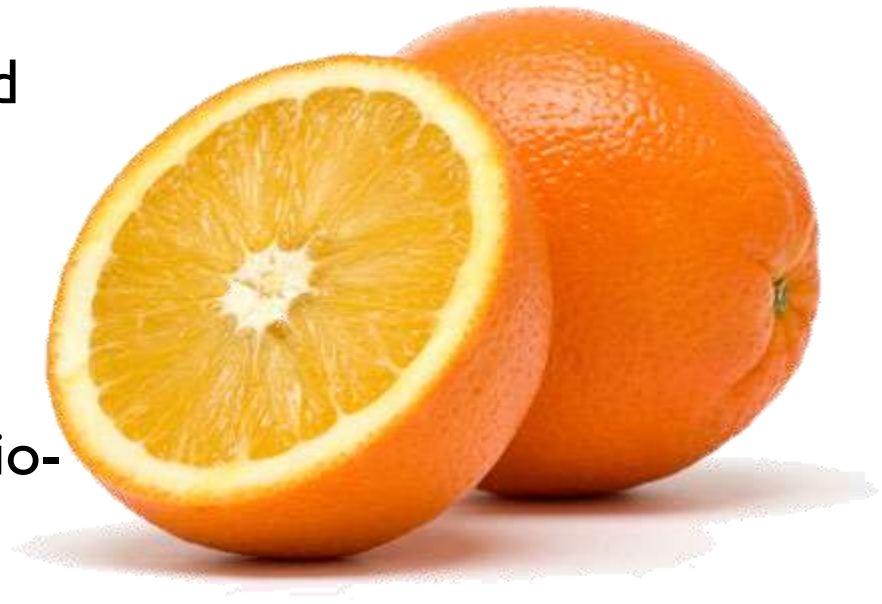




# Conclusions

---

- ▶ Assumptions about how diets around the world will develop have a large effect on global land use and biomass availability.
- ▶ Increased animal consumption requires more land and bioenergy potential is reduced.
- ▶ It is possible that a healthy diet may also require a lot of land and could reduce bioenergy potential.
- ▶ A global vegetarian diet can leave a lot of land to produce bio-energy and leave natural areas.





# Contact

---

Dr. Jay S. Gregg<sup>1</sup>

[jsgr@dtu.dk](mailto:jsgr@dtu.dk)

Dr. Katherine Calvin<sup>2</sup>

[katherine.calvin@pnnl.gov](mailto:katherine.calvin@pnnl.gov)

M.Sc. Anna Hvid<sup>1</sup>

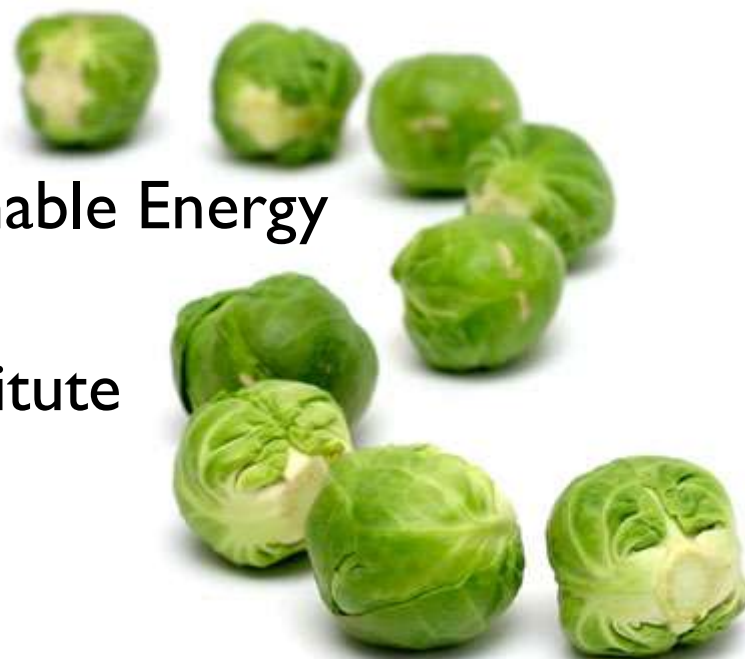
[anhv@dtu.dk](mailto:anhv@dtu.dk)

## Affiliations:

1: Technical University of Denmark

Risø National Laboratory for Sustainable Energy

2: Joint Global Change Research Institute



---

***Thank you!***